PART 6

GENERAL ELECTRICAL REQUIREMENTS

Table of Content
Part 6

6.1 INTRODUCTION 5

6.2 EQUIPMENT 5

6.3 TRANSFORMERS 5

6.3.1 APPLICABLE STANDARDS 5
6.3.2 FEATURES OF CONSTRUCTION 6
6.3.3 WINDING CONNECTIONS 7
6.3.4 RATING 7
6.3.5 TYPE OF COOLING 7
6.3.6 IMPEDANCE AND LOSSES 7
6.3.7 PERFORMANCE REQUIREMENTS 7
6.3.8 TAP CHANGER 8
6.3.9 ON LOAD TAP CHANGING GEAR FOR TRANSFORMER (ABOVE 500KVA) 8
6.3.10 OFF LOAD TAP CHANGING MECHANISM FOR TRANSFORMER (LESS THAN OR EQUAL TO500KVA) 10
6.3.11 FITTINGS AND ACCESSORIES 10
6.3.12 CABLE TERMINATIONS / CABLING REQUIREMENT 12
6.3.13 TOLERANCE ON LOSSES 12
6.3.14 REJECTION 12
6.3.15 DRAWINGS AND DATA 12

6.4 HT METAL ENCLOSED SWITCHBOARDS& SWITCHGEARS 12

6.4.2 CONSTRUCTIONAL FEATURES 13
6.4.3 CIRCUIT BREAKER 15
6.4.4 OPERATING MECHANISM CONTROL 15
6.4.5 SAFETY INTERLOCKS AND FEATURES 16
6.4.6 EARTHING 17
6.4.7 CIRCUIT / BUSBAR EARTHING FACILITY 17
6.4.8 ANNUNCIATORS 17
6.4.9 INDICATING INSTRUMENTS & METERS 18
6.4.10 CONTROL AND SELECTOR SWITCHES 18
6.4.11 INDICATING LIGHTS / PILOT LIGHTS 19
6.4.12 PUSH BUTTONS 19
6.4.13 SPACE HEATERS 20
6.4.14 CUBICLE LIGHTING / RECEPTACLE 20
6.4.15 POWER AND CONTROL CABLE TERMINATION 20
6.4.16 WIRING FOR CONTROL AND PROTECTIVE CIRCUITS 21
6.4.17 TERMINATION AND FERRULES 21
6.4.18 CONTROL WIRING TERMINAL BLOCKS 21
6.4.19 BUS BARS 22
6.4.20 CURRENT & VOLTAGE TRANSFORMERS 22
6.4.21 RELAYS 23
6.4.22 ENERGY MONITORING AND POWER SUPPLY MANAGEMENT 23
6.4.23 I/O SIGNAL FOR INSTRUMENTATION, CONTROL & AUTOMATION SYSTEM FROM ELECTRICAL PANELS. 24
6.4.24 DRAWINGS AND DATA 24

6.5 415V METAL ENCLOSED SWITCHGEARS (PCC / MCC) 24

6.5.1 APPLICABLE STANDARDS 24
6.5.2 GENERAL 25
6.5.3 AIR CIRCUIT BREAKER (ACB) 28
6.5.4 MOTOR PROTECTION RELAY 29
6.5.5 MOULDED CASE CIRCUIT BREAKER (MCCB) 29
6.5.6 SWITCHES 30
6.5.7 MINIATURE CIRCUIT BREAKER (MCB) 31
6.5.8 CONTACTORS 31
6.5.9 CURRENT TRANSFORMERS / CBCT 31
6.5.10 INDICATING INSTRUMENTS & METERS 31
6.5.11 INDICATING LIGHTS 32
6.5.12 PUSH BUTTONS 32
6.5.13 SPACE HEATERS 32
6.5.14 SAFETY ARRANGEMENTS 32
6.5.15 EARTHING OF SWITCHBOARDS / PANELS 32
6.5.16 INTERNAL WIRING 32
6.5.17 I/O FOR INSTRUMENTATION, CONTROL & AUTOMATION SYSTEM FROM ELECTRICAL PANELS 33
6.5.18 DRAWINGS AND DATA 33
6.6 POWER CAPACITOR AND APFC CONTROL PANEL (415V) 33
6.6.1 APPLICABLE STANDARDS 33
6.6.2 DESIGN FEATURES 33
6.6.3 POWER CAPACITOR AND CONTROL PANEL 34
6.6.4 DRAWINGS AND DATA 35
6.7 SOFT STARTERS 35
6.7.1 APPLICABLE STANDARDS 35
6.7.2 CONSTRUCTIONAL AND PERFORMANCE FEATURES 36
6.7.3 MAIN BUSBARS 37
6.7.4 EARTHING 38
6.7.5 PANEL ACCESSORIES AND WIRING 38
6.7.6 CABLE TERMINATION 39
6.7.7 DRAWINGS AND DATA 39
6.8 DIESEL STANDBY GENERATOR 39
6.8. 1 APPLICABLE STANDARDS 39
6.8. 2 GENERAL REQUIREMENTS 40
6.8. 3 DIESEL GENERATING SET AUTOMATIC CONTROL 41
6.8. 4 ALTERNATOR FOR DIESEL GENERATING SET 41
6.8. 5 DIESEL ENGINE FOR GENERATING SET 42
6.8. 6 DIESEL GENERATOR CONTROL PANEL: 43
6.8. 7 SYNCHRONISING PANEL 44
6.8. 8 ACOUSTIC ENCLOSURE 44
6.8. 9 DRAWINGS AND DATA 45
6.9 UPS, BATTERY, BATTERY CHARGER AND D.C DISTRIBUTION BOARD 45
6.9.1 GENERAL REQUIREMENTS 45
6.9.2 NICKEL - CADMIUM BATTERY 45
6.9.3 DRAWING 46
6.9.4 BATTERY CHARGER AND D.C. DISTRIBUTION BOARD 46

6.9.5 BATTERY CHARGER 47
6.9.6 CHARGER PANEL AND D.C. DISTRIBUTION BOARD 48
6.9.7 COMPONENTS/ACCESSORIES 49
6.9.8 POWER ELECTRONIC COMPONENTS 50
6.9.9 DRAWINGS AND DATA 50
6.10 VARIABLE FREQUENCY DRIVES 50
6.10.1 APPLICABLE STANDARDS 51
6.10.2 CONFIGURATION 51
6.10.3 CONVERTER 51
6.10.4 INVERTER 52
6.10.5 INVERTER FOR AC DRIVE 52
6.10.6 OUTPUT OVERCURRENT LIMIT 53
6.10.7 CONTROL MODULES 53
6.10.8 CONTROL REQUIREMENTS 53
6.10.9 PROTECTION 53
6.10.10 COOLING OF POWER CONVERTERS 54
6.10.11 SWITCHING DEVICES 54
6.10.12 CONSTRUCTIONAL FEATURES 54
6.10.13 BINS AND PRINTED CIRCUIT CARDS 56
6.10.14 ANNUNCIATION 56
6.10.15 METERS 57
6.10.16 WIRING 57
6.11 ELECTRICAL MOTORS 57
6.12.1 General 57
6.12.2 Construction 58
6.12.3 Performance and Characteristics of LT Motor 58
6.12.4 Specific Requirements of VFD Driven Motors 59
6.12.5 Local Push Button Station 59
6.12.6 Cable Terminations 60
6.12.7 Junction Boxes 60
6.12 CABLES: HV, LV POWER, CONTROL AND TELECOMMUNICATIONS 60
6.13.1 APPLICABLE STANDARDS 60
6.13.2 FEATURES OF CONSTRUCTION 61
6.13.3 CABLE RATING 61
6.13.4 CABLE COLOURS 62
6.13.5 CABLE CONDUCTORS 62
6.13.6 CABLE NUMBERING 62
6.13.7 CABLE DRUMS 62
6.13.8 CABLE INSTALLATION 63
6.13.9 CABLES LAID DIRECT IN GROUND 64
6.13.10 CABLES LAID IN UNDERGROUND DUCTS 64
6.13.11 CABLES INSTALLED IN CONDUIT 64
6.13.12 CABLE INSTALLED IN FLEXIBLE CONDUIT 66
6.13.13 CABLE INSTALLED IN CABLE TRUNKING – METAL 66
6.13.14 CABLE INSTALLED ON CABLE TRAY 67
6.13.15 CABLE INSTALLED ON LADDER RACK SYSTEMS 67

6.13.16 Cable Clipped Direct 68
6.13.17 Cable Installed in Internal Floor Trench 68
6.13.18 Cable Terminations and Joints 68
6.13.19 Cable Fixings 69
6.13.20 Cable Glands 69
6.13.21 Drawings and Data 70
6.13 CABLE CARRIER SYSTEM 70
6.14.1 General 70
6.14.2 Applicable Standards 70
6.14.3 Galvanising 71
6.14.4 Drawings and Data 71
6.14 LIGHTING SYSTEM 71
6.15.1 General Requirements 71
6.15.2 Construction of LED luminaires 72
6.15.3 Applicable codes & standards 72
6.15.4 Tests 73
6.15.5 Earthing 73
6.15.6 Lighting System Equipment 74
6.15.7 Lighting Fixtures (Luminaires-LED) 75
6.15.8 Accessories for Luminaires 77
6.15.9 Galvanized Octagonal Poles for Street Lighting 79
6.15.10 Drawings and Data 80
6.15.11 Lighting System Equipment 80
6.15.12 Drawings and Data 84
6.15 RENEWABLE ENERGY CAPABILITY 84
6.16.1 Solar PV Rooftop system for street lighting only 84
16.6.2 The Centralized solar lighting systems shall comprise: 84
6.16 EARTHING AND LIGHTING PROTECTION SYSTEM 85
6.17.1 General 85
6.17.2 Applicable Standards 85
6.17.3 Earthing Conductor 85
6.17.4 Lightning Protection System 86
6.17.5 Main Equipotential Bonding Conductor 86
6.17.6 Circuit Protective Conductors 87
6.17.7 Instrumentation Earth 88
6.17.8 Galvanising 88
6.17 INSULATING MAT 89
6.18 PREFERRED MAKES/MANUFACTURERS 89
11 kV Metal enclosed switchboards 89

PART 6

GENERAL ELECTRICAL REQUIREMENTS

6.1 Introduction

The general requirements include design, manufacture, inspection and testing at works, supply and delivery at site, unloading and storing the equipment at site of installation, testing and commissioning of the equipment at site listed below. All the electrical and instrumentation equipment to be supplied under this contract have to be of reputed makes. The equipment of those manufacturers, who have sufficient proven experience of manufacturing the respective equipment of similar capacity, shall be considered. The respective equipment should have been manufactured, supplied, installed, commissioned successfully and should be running satisfactorily since at least last 5 years continuously. Certificates from the end users, regarding their satisfactory Performances, shall have to be submitted in this regard. All equipment shall be OEM (Original Equipment manufacturer) type only.

Particular requirements of all electrical equipment are covered under 'Part 12: Particular Requirements – Electrical' of this Specification. All the equipment /items shall conform to latest applicable standards specified. In case of Conflict between standards and this specification, this specification shall govern.

6.2 Equipment

(a) Transformers
(b) HT Metal enclosed switchboards & switchgears
(c) 415V Metal enclosed switchgears (PCC) /MCC
(d) Power capacitor and control panel
(e) Soft Starters
(f) Bus Duct
(g) Diesel Standby Generator with AMF Control Panel and Synchronizing panel
(h) Battery, battery charger and DC Distribution Board
(i) Variable Frequency Drives
(j) Power, control and telecommunication cables
(k) Cable carrier system
(l) Lighting system
(m) Earthing and lightening protection systems
(n) Fire MCC Panel (emergency DB)
(o) Fire alarm and protection system

6.3 Transformers

Transformer system shall have provision such that inter-operability with instrumentation controls system.

6.3.1 Applicable Standards

The transformers shall conform to the latest applicable standards specified below:

Power Transformer	IS:2026/BS:171/IEC:60076 IS11171

Fittings and Accessories	IS:3639
Outdoor type Oil immersed distribution transformers up to 2500kVA, 33kV Transformer	IS:1180
Procedure for testing	IS: 1180 / 2026
Loading of oil immersed transformer	IS:6600/BS: CP.1010 /IEC:60354
Transformer Oil	IS:335/BS 148/IEC:60296
Bushings for > 1000V, AC	IS:2099/BS:223/IEC:60137
Bushings for ≤ 1000V, AC	IS:7421
Degree of Protection	IS:13947 (Part 1)/IEC:60947-1
Double float type Buchholz Relay	IS:3637
Electrical insulation classified by thermal stability	IS 1271/BS:2757/IEC:60085
Climate Proofing	BS: CP1014
Code of Practice for selection, installation and Maintenance of transformers	IS - 10028
Manual on Transformers	CBIP Publication No.317

6.3.2 Features of Construction

The transformer tank shall be made from high-grade sheet steel, suitably reinforced by stiffeners made of structural steel sections. All seams, flanges, lifting lugs, braces, and other parts attached to the tank shall be welded. The interior of the tank shall be cleaned by sand blasting and painted with two coats of heat resistant, oil insoluble paint. Adequately sized manholes shall be provided for ease of inspection and maintenance. Steel bolts and nuts exposed to atmosphere, shall be galvanized. The tank cover shall be removable and shall be suitably sloped so that it does not retain rainwater.

Lifting lugs and eyebolts shall be so located that a safe clearance shall be obtained without the use of a spreader, between the sling and transformer bushings.

Transformers shall be provided with fixed type radiators. Fins of the radiators shall not have sharp edges and shall be rounded in shape.

The transformer core shall be constructed from high grade, non-ageing, cold-rolled, grain oriented, silicon steel laminations. The steel laminations shall be of "core" type. Each lamination shall be coated with insulation which shall be unaffected by the temperature attained by the transformer during service. Core laminations shall be annealed, and burrs removed after cutting. Cut edges shall be insulated. The framework and clamping arrangements of core and coil shall be securely earthed inside the tank by a copper strap connection to the tank.

Windings shall be of insulated copper wire or copper strip. Windings and insulation shall be so arranged that free circulation of oil shall be possible between coils, between windings, and between winding and core. The windings shall be fully shrunk under vacuum before assembly. High voltage end-windings shall be suitably braced to withstand short circuit stresses and stresses caused up by surges.

The sequence and orientation of HV/LV side phase and neutral bushings shall be as specified in the latest edition of relevant IS.

Transformer shall operate without injurious heating at the rated KVA and at any voltage up to + 10% of the rated voltage of any tap. Transformer shall be designed for 110% continuous over-fluxing withstanding capability.

Transformer shall be provided with Zero sequence / earth fault current protection on LV side transformer feeder protection. (Neutral CT to be provided in case of solid grounding)

6.3.3 Winding Connections

Windings shall be of HV: Delta & LV: Star, vector group Dyn11.

6.3.4 Rating

The rating of transformers shall be as per standard ratings shown in IS 1180 (latest revision) / CBIP Publication.317.

6.3.5 Type of cooling

The transformers shall be oil immersed with natural oil circulation, type ONAN (Oil Natural Air Natural). With the provision for radiator cooling with fans for forced cooling, if required will be added in future. The rating of the transformer with ONAF (Oil Natural Air Forced) shall be specified.

6.3.6 Impedance and losses

The percentage impedance shall be as per IS 1180, no load & load losses shall be as per IS 1180 (latest revision) under revised BEE star-2 category.

6.3.7 Performance requirements

(a) The transformers shall be suitable for operation without danger on to any particular tapping at the rated kVA provided that the voltage does not vary by more than ± 10% of the voltage corresponding to the tapping.

(b) The transformers shall be suitable for continuous operation with a frequency variation of ±5% of rated frequency, combined voltage and frequency variation should not exceed 10%.

(c) All transformers shall be capable of withstanding external short circuit without damage as per IS 2026.

(d) The transformers shall be capable of continuous operation in accordance with relevant IS for loading of oil immersed transformers.

(e) The neutral terminal of star windings shall be designed for the highest over current that can flow through this terminal.

(f) The temperature rise of oil & windings over the specified ambient temperature shall not exceed the limits given below with air as cooling medium when tested in accordance with IS 2026 (Part-2).

Top oil (measured by thermometer)	:	35° C
Winding (measured by resistance)	:	40° C

(g) Noise level of transformers shall be less than 85dB (NEMA standard) at a distance of 1.86 metre.

6.3.8 Tap Changer

For transformer of rating less than or equal to 500kVA, tap changing shall be carried out by means of an off circuit externally operated self-positioning switch when the transformer is in de-energized condition. Off circuit tapping arrangement shall be either by means of an externally operated switch with mechanically locking device and a position indicator. Arrangement for pad-locking shall be provided. Tapings shall be provided on the higher voltage winding for variation of HV voltage from plus 5% to minus 10% in steps of 2.5%.

For transformer of rating greater than 500kVA on load tap changer may be provided on HV side for variation HV voltage from plus 5% to minus 15% in steps of 2.5% with Remote Tap Changing Controller (RTCC), Automatic Voltage Regulator (AVR) etc.

6.3.9 On Load Tap Changing Gear for Transformer (above 500kVA)

(a) The OLTC gear shall be designed to complete successfully tap changes for the maximum current to which transformer can be loaded i.e., 150% of the rated current. Devices shall be incorporated to prevent tap change when the through current is in excess of the safe current that the tap changer can handle. The OLTC gear shall withstand through fault currents without injury.

(b) When a tap change has been commenced it shall be completed independently of the operation of the control relays and switches. Necessary safeguard shall be provided to allow for failure of auxiliary power supply or any other contingency which may result in the tap changer movement not being completed once it shall be commenced.

(c) Oil in compartments which contain the making and breaking contacts of the OLTC shall not mix with oil in other compartments of the OLTC or with transformer oil. Gases released from these compartments shall be conveyed by a pipe to a separate oil conservator or to a segregated compartment within the main transformer conservator. A Buchholz relay shall be installed in the above pipe. The segregated compartment (conservator) shall be provided with a prismatic oil level gauge.

(d) Oil, in compartments of OLTC which do not contain the make and break contacts, shall be maintained under conservator head by valve pipe connections. Any gas leaving these compartments shall pass through the Buchholz relay before entering the conservator.

(e) Oil filled compartments shall be provided with filling plug, drain valve with plug, air release vent, oil sampling device, inspection opening with gasketed and bolted cover with lifting handle.

(f) OLTC driving mechanism and its associated control equipment (Local) shall be mounted in an outdoor, weather-proof cabinet with IP65 protection which shall include:
(i) Driving motor (415V, 3-phase, 50 Hz. AC squirrel cage).
(ii) Motor starting contactor with thermal overload relays, isolating switch and MCB.

(iii) Duplicate sources of power supply with automatic changeover from the running source to the standby source and vice versa.
(iv) Control switch: Raise/ Off/ Lower (spring return to normal type).
(v) Remote/Off/Local selector switch (maintained contact type).
(vi) Mechanical tap position indicator showing rated tap voltage against each position and resettable maximum and minimum indicators.
(vii) Limit switches to prevent motor over-travel in either direction or final mechanical stops.
(viii) Brake or clutches to permit only one tap change at a time on manual operation.
(ix) Emergency manual operating device (hand crank or hand wheel).
(x) A five digit operation counter.
(xi) Electrically interlocked reversing contactors (preferably also mechanically interlocked).
(xii) 240V, 50 Hz. AC space heater with thermostat and MCB.
(xiii) Interior lighting fixture with lamp door switch and MCB.
(xiv) Gasketed and hinged door with locking arrangement.
(xv) Terminal blocks, internal wiring, earthing terminals and cable glands for power and control cables.
(xvi) Necessary digital protection relays, contactors, current transformers etc.

(g) Control Requirements for OLTC

The following electrical control features shall be provided:
(i) Positive completion of load current transfer, once a tap change has been initiated, without stopping on any intermediate position, even in case of failure of external power supply.
(ii) Only one taps change from each tap change impulse even if the control switches or push button shall be maintained in the operated position.
(iii) Cut-off of electrical control when manual control shall be resorted to. Cut-off of a counter impulse for a reverse tap change until the mechanism comes to rest and resets the circuits for a fresh operation.
(iv) Cut-off of electrical control when it tends to operate the tap beyond its extreme position.

(h) Automatic Control of OLTC

Automatic OLTC control shall include the following items:
(i) Voltage setting device
(ii) Voltage sensing and voltage regulating devices.
(iii) Line drop compensator with adjustable R and X elements.
(iv) Timer 5-25 seconds for delaying the operation of the tap changer in the first step for every tap change operation.
(v) Adjustable dead band for voltage variation

(i) OLTC Panel:

The OLTC remote control equipment shall be suitable for 110V DC supply and shall be housed in an indoor sheet steel cubicle to be located in a remote-control room. The OLTC control panel shall comprise of rigid welded structural frames made of structural steel section or of pressed and formed cold rolled steel and frame enclosures, doors and partitions shall be of cold rolled steel of thickness 2mm. Stiffeners shall be provided wherever necessary. All doors, removable covers and plate shall be gasketed all around with neoprene gaskets. Panel shall be dust, weather and vermin proof providing degree of protection of IP54, colour of finish shade for interior and exterior shall be glassy white and light grey semi glossy shade 631 of IS-5 respectively. Earthing bus shall be of 25 x 6 mm copper.

The OLTC remote control equipment shall comprise of the following:

(i) Control switch : Raise / Off / Lower (Spring return to normal type)

(ii) Auto / Off / Manual selector switch (Maintained contact type).

(iii) Tap position indicator.

(iv) Fascia type alarm annunciations with "accept" and "lamp test" facilities.

- A.C. supply failure.
- Drive motor auto tripped.
- Tap change delayed.

(v) Necessary auxiliary relays.

(vi) Lamp indications for:

- Tap change in progress.
- Lower limit reached.
- Upper limit reached.

(vii) Double compression Cable glands for power and control cables.

(viii) 240 V rated panel space heater with thermostat and ON-OFF MCB.

(ix) LED type Energy efficient (lumen per Watt shall be specified) interior lighting fixture with lamp and door switch.

(x) MCB / HRC fuses.

(xi) Terminal blocks.

(xii) Internal wiring.

(xiii) Earthing terminal.

6.3.10 Off Load Tap Changing Mechanism for Transformer (Less than or equal to500kVA)

Off circuit tap changing mechanism shall comprise the following:

Operating handle of wheel, accessible from ground level.

Tap position indicator.

Pad locking arrangement.

The tap-changer connections and contacts shall be accessible through an access hole having a bolted gasketed cover.

6.3.11 Fittings and Accessories

The following fittings and accessories shall be provided with transformer:

(a) Name plate, rating plate and diagram plate as per IS 1180.

(b) Two earthing terminals on opposite ends of the transformer tank.

(c) Neutral earthing bar of copper of specified section installed from the neutral bushing to ground level suitably supported along its run on porcelain insulators, together with clamping arrangements at neutral bushing and for two Employer's earth conductors. The supporting insulators shall be tank mounted.

(d) Inspection manhole(s) with cover(s) on the top cover of the transformer.

(e) Lifting lugs or eyes for lifting of fully assembled transformer, core assembly and tank core by crane.

(f) Conservator, complete with filling plug, sump and drain valve, and a shut-off valve on the pipe connection between transformer tank and conservator, to permit removal of the conservator.

The conservator shall be designed to maintain an oil seal through a temperature range of 100 Deg C.

(g) Oil level indicator with minimum marking.

(h) Weather proof dehydrating breather with clear polycarbonate desiccant container weight of the desiccant shall meet 400 charge life days. Desiccant type shall be self-indicating bread silica gel as the dehydrating agent.

(i) For all transformers, magnetic type oil level gauge with low oil level alarm contact, mounted on the conservators with waterproof and dustproof terminal box and shall be wired to marshalling box.

(j) Gas detector relays with separate alarm and trip contacts complete with shut-off valves shall be wired to marshalling box.

(k) Separate drain valve, oil sampling valve with plug and top filter valve shall be provided on the tank and shall be leak proof after commissioning.

(l) Explosion vent with diaphragm for relieving pressure inside the transformer. The device shall be rain proof after operation. For transformers of 500KVA and above an equalizer pipe connecting the pressure relief device to the conservator shall be supplied.

(m) Separately mounted, water proof and dustproof marshalling box housing the buchholz relay wiring, oil level low wiring, oil temperature indicator and winding temperature indicator with alarm and trip contacts and marshalling facilities for electrical devices mounted on transformer including load management signal shall be provided to give an information about the over loading condition of the transformer and all signals shall be wire able to alarm annunciation. (The signal shall not give indication for momentary over loading). The marshalling box shall be in accordance with IS 2147. The degree of protection shall be IP65 with space heaters etc.

(n) For transformers rated 500KVA and above. Adequate number of air vents for relieving trapped air during oil filling / during maintenance and shall be leak proof after commissioning.

(o) Thermometer pockets and sensing element mounted on the transformer tank cover for measuring top oil temperature.

(p) Four jacking pads for lifting the transformer with jacks.

(q) Pulling eyes and skids for the movement of the transformer.

(r) Bidirectional wheels for movement of the transformer.

(s) A ladder assembly shall be provided to reach the top of the transformer for maintenance work. It shall be possible to padlock the ladder to the transformer tank so that ladder cannot be removed. Usage of transformer structure / marshalling boxes etc. as means to climb transformer are not acceptable.

(t) Accessories for clamping the wheel mounted transformer to the foundation in order to withstand earthquake forces with a seismic acceleration of 0.2g.

(u) Transformer shall be supplied complete with insulating oil required for first filling plus 10% excess oil in non-returnable drums (With gas analysis report).

6.3.12 Cable Terminations / Cabling Requirement

Cable termination boxes for transformers shall be suitable for dry termination of HV and LV cables. Non-magnetic gland plates shall be provided for the termination of cables. Maximum size of the cable and number of cables that can be terminated shall be indicated.

It shall be possible to remove the cable boxes without dismantling the cable glanding or draining the oil. Disconnecting links shall be provided to facilitate testing of the cable.

All transformers shall be provided with alarm annunciation on breaker control panel.

6.3.13 Tolerance on Losses

The permissible tolerances on the guaranteed values of transformer losses shall be as per IS 2026. The values of load- losses and No-load losses shall be within the values given in latest edition of CBIP manual(star-5) for transformers / IS 1180 under revised BEE star-2 category.

Cost loading shall be done for capitalization of losses at time of bid evaluation for all transformers as per CBIP Manual on transformers.

6.3.14 Rejection

The Employer or Employer's Representative reserves the right to reject the transformer if the same does not meet the specification requirement, subject to tolerances as per IS 2026. The impedance values difference and temperature rise values shall not exceed from the guaranteed specified values. The rejected transformers shall be replaced by transformers complying with the requirements of this specification at the Contractor's cost.

If the commissioning of the project shall be likely to be delayed by the rejection of a transformer, the Employer's Representative reserves the right to accept the rejected transformer until the replacement transformer shall be made available. Transporting the rejected and replacement transformers as well as installation and commissioning of both the transformers shall be at the Contractor's cost.

6.3.15 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.4 HT Metal Enclosed Switchboards& Switchgears

HT Metal enclosed Switchboards and Switchgear system shall have provision such that inter-operability with instrumentation control system.

6.4.1 Applicable Standards

The switchgear and its components shall conform to the latest applicable standards specified below:

Circuit Breakers	IS: 13118 / BS: 5311 / IEC: 60056,60694, IEC 62271-100
Metal Enclosed switchgear	IS: 3427 / BSEN:60298 / IEC:60298, IEC 62271-200
Current Transformers	IS: 2705 / BS: 7626
Voltage Transformers	IS: 3156 / BS: 7625 / IEC: 60186
Arrangement for Switchgear Busbars, Main Connections and Auxiliary wiring	IS: 5578, 11353
Busbar Support insulators	IS: 2544 / BS: 3297 / IEC:60 273
Degree of Protection	IS:13947 (Part 1) / IEC: 60947-1 / BSEN: 60529
Electrical Relays for Power system protection	IS: 3231, 3842 / BS: 142/EC: 60255
Electrical Indicating Instruments	IS: 1248 / BS: 89 / IEC:60051
High Voltage Fuses	IS: 9385 / BS: 2692 / IEC: 60282
AC Electricity Meters	IS: 722, 8530 / BS: 5685 / IEC: 60145,60211
Specification for copper rods and bars for electrical purposes	IS: 613
Code of practice for phosphate coated iron and steel	IS: 6005 / BS: 3189
Alternating current Switches for voltages above 1000V	IS: 9920 / IEC: 60129,60265 & 60298
Low voltage fuses	IS: 13703 / BS 1362 / IEC 60269
Toggle switches	IS: 3452 / BS: 3676
Code of practice for selection, installation and maintenance of switchgear and control gear	IS: 10118
Control switches	IS:6875 / BSEN 60947 / IEC: 60947
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS 5572, IS 5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC 60079
Fault level calculation	IS: 13234 / IS:2026

6.4.2 Constructional Features

Switchgear design shall be of metal enclosed, single front, free standing, floor mounted and fully compartmental execution having separate sections for each circuit. Each Circuit shall have a separate vertical panel with distinct compartments for main bus bars, circuit breaker, cable termination and auxiliary devices. The adjacent panels shall be completely separated by steel sheets except in bus bar

sheet compartments where insulated barriers shall be provided to segregate adjacent panels. Compartments with doors for access to operating mechanism shall be so arranged as not to expose high voltage circuits. Switchgear cubicle shall be provided with hinged door on the front with facility for locking door handle. Stiffeners shall be provided wherever necessary to strengthen the door and side covers. Switchboard shall be dust and vermin-proof and shall have a degree of protection of enclosure of IP 4X and the relay and meter compartments shall have a degree of Protection not less than IP 52. All removable covers shall be gasketed all around with neoprene or superior gaskets.

Instruments, relays and control devices shall be flush-mounted on hinged door of the metering compartment located in the front portion of cubicle. The metering compartment shall be properly shielded to prevent maloperation of electronic equipment such as numerical / static relays due to electro-magnetic fields. All transformers shall be provided with alarm annunciation on breaker control panel.

Each switchgear cubicle shall be fitted with a label on the front and rear of the cubicle. Each switchboard shall also be fitted with label indicating the switchboard designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate label.

The fully draw-out modules shall have all the circuit components mounted on withdrawable type steel chassis. All power and control connections shall be of the draw out type. It shall be possible to withdraw the chassis mounted circuit components without disconnecting any connections. All draw out contacts shall be of silver-plated copper.

In case of circuit breaker compartments, suitable barriers shall be provided between breaker and all control, protective and indication circuit equipment including instrument transformers such that no live parts are accessible. External cable connections shall be through separate cable compartments for power and control cables. Safety shutters shall be provided to cover up the fixed high voltage contacts on busbars when the circuit breaker carriage shall be moved to ‘test’ and ‘isolated’ positions.

One metal sheet shall be provided between two adjacent vertical sections running to the full height of the switchboard except for the horizontal busbar compartment. However, each shipping section shall have metal sheets at both ends. After isolation of the power and control connections of a circuit, it shall be possible to carry out maintenance in a compartment safely, with the busbars and adjacent circuits alive.

All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate coated Iron and Steel”. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphate coated, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying.

The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.

The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 120 microns. Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.

A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

6.4.3 Circuit Breaker

Circuit breakers shall be vacuum type with three separate single pole interrupting units, operated through a common shaft by a sturdy operating mechanism. Surge Arrestors shall be provided for each motor / transformer feeder. Circuit Breakers shall be re-strike free, stored energy operated and trip free type. Circuit breaker along with its operating mechanism shall be mounted on a wheeled carriage moving on guides, designed to align correctly and allow easy movement. Plugs and sockets for power circuits shall be silver faced and shall be insulated with suitable insulating material shrouds. All corresponding components of circuit breaker cubicles of same rating shall be interchangeable with one another. Anti-pumping relay and trip coil suspension relay shall be provided.

There shall be 'Service', 'Test' 'Fully withdrawn' positions for the breakers. In the 'Test' position the circuit breaker shall be capable of being tested for operation without energizing the power circuits, i.e. the control circuits shall remain undisturbed while the power contacts shall remain disconnected. Separate limit switches, each having a minimum of 2 'NO' + 2 'NC' contacts, shall be provided for both 'Service' and 'Test' positions of the circuit breakers. All these service, test, fully withdrawn, spring charge and also breaker ON / OFF shall be visible mechanically from outside the breaker panel when the front door is closed.

Electrical closing &tripping shall be performed by shunt trip & close coils both in Local, Off & Remote mode, selector switch lockable in "Local" position shall be provided on the cubicle door. 'Red' and 'Green' indicating lamps shall be provided on cubicle door to indicate breaker close and open positions. Breaker "Service", "Test" and "breaker readiness" positions shall be indicated by separate indicating lamps on the cubicle door.

Connection of the control / interlocking circuits between the fixed portion of the cubicle and the breaker carriage shall be preferably by means of plug socket arrangement.

10% spare feeders with at least one for each type of highest rating shall be provided in each switchgear.

Surge arrestors shall be provided for all incomer and transformer feeders, which shall be metal oxide gapped or gapless, type generally in accordance with IEC 60099-1and suitable for indoor only.

6.4.4 Operating Mechanism Control

- Circuit breakers shall be operated by a motor spring charging type of mechanism. The mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.
- Operating mechanism shall normally be operated from the breaker cubicle itself.
- The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the

mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency. Transfer from motor to manual charging shall automatically disconnect the charging motor. All operating mechanisms shall be provided with "ON" - "OFF" mechanical indication. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

- Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) shall be being held in the "close" position.
- The circuit breaker mechanism shall make one complete closing operation, once the push button (PB) or control switch has been operated and the first device in the control scheme has responded, even though the PB or control switch shall be released before the closing operation shall complete, subject to the condition that there is no counter-impulse for tripping.
- Means shall be provided to manually open and close the breakers slowly, when the operating power shall not be available, for maintenance and adjustments. A local manual trip device shall also be provided on the operating mechanism.
- Circuit breaker control shall be on 110V DC. Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 80-110% of the control voltage. Trip coils shall operate satisfactorily between 50 -110% the rated control voltage.

6.4.5 Safety Interlocks and Features

- Withdrawal or engagement of a circuit breaker shall not be possible unless it shall be in the open position.
- All circuit breaker shall have lockable local / off/ remote selector switch, for closing the breaker from local shall be possible in both TEST / SERVICE position. Closing from remote shall be possible in either SERVICE or TEST position. For opening breaker from local shall be possible only when local/off/remote selector switch shall be in local position. Opening breaker from remote shall be either breaker in service position or selector switch being in remote position.
- All Motors and Service Transformers feeder breaker shall have lockable emergency push button (open able only with key) near motor and service transformer, hard wired to circuit breaker panel emergency push button.
- Operation of a circuit breaker shall not be possible unless it shall be in service position, withdrawn to test position or fully drawn out. It shall not be possible to close the circuit breaker electrically in the service position, without completing the auxiliary circuit between the fixed and moving portions.
- Circuit breaker cubicles shall be provided with safety shutters operated automatically by the movement of the circuit breaker carriage to cover the stationary isolated contacts when the breaker shall be withdrawn. Padlocking facilities shall be provided for locking the shutters positively in the closed position. It shall, however, be possible to open the shutters intentionally against spring pressure for testing purposes.
- The circuit breaker carriage shall be earthed before the breaker reaches the test position from fully withdrawn position. In case of breakers with automatic disconnecting type of auxiliary disconnects, the carriage shall be earthed before the auxiliary disconnects are made and the carriage earthing shall break only after the auxiliary disconnects break.
- Caution nameplate, “Caution Live Terminals” shall be provided at all points where the terminals are likely to remain live and isolation shall be possible only at remote end, i.e. incomer to the switchboard. Suitable interlock shall be wired for the purpose.

6.4.6 Earthing

Copper earthing bus shall be provided and extended throughout the length of the switchboard. It shall be bolted to the framework of each unit and brazed to each breaker earthing contact bar. It shall be located at the bottom of the board. The earth bus shall have sufficient cross section to carry the momentary short circuit and short time fault current for at least 1 second or higher without exceeding maximum allowable temperature rise. The earth bus shall be properly supported to withstand stresses induced by the momentary short circuit current.

Suitable clamp type terminals at each end of the earth bus shall be provided to suit the size of the earthing conductors. Bolted joints, slices, tap, etc. to the earth bus shall be made with at least two bolts. Positive earthing of circuit breaker frame shall be maintained when it shall be in the connected position and in all other positions whilst the auxiliary circuits are not totally disconnected.

Hinged doors shall be earthed through flexible earthing braid of adequate cross section. All non-current carrying metal work of the switchboard shall be effectively bonded to the earth bus.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth busbar shall be maintained through insulated conductors of size equal to the earth busbar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth busbar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5sq. mm conductor looped through each of the earth terminals.

6.4.7 Circuit / Busbar Earthing Facility

It shall be possible to connect each circuit or set of 3 phase bus bars of the switchboard to earth through earthing switches. Earthing switches / earthing devices shall be mechanically interlocked with the associated breakers to prevent accidental earthing of live circuit or bus bars.

In case the earthing facility comprises earthing trucks to be inserted in place of circuit breakers, separate earthing trucks shall be supplied for each type / size of breaker. The earthing facilities proposed to be provided by the Bidder shall be clearly detailed in the Bid and shall be subject to Employer's approval. Auxiliary contacts (min. 2 NO + 2 NC) shall be provided on each earth switch / earthing device and shall be wired to the terminal block for interlocking purpose.

6.4.8 Annunciators

Annunciators shall be of fascia type with translucent plastic window for each alarm point. Enunciated fascia plates shall be engraved in block lettering with respective alarm inscriptions. The inscriptions shall be clearly readable and visible when the respective fascia LED light shall be lighted. Each annunciation window shall be provided with two LED lights to provide redundancy against LED light failure. Lamps shall be replaceable from the front. Lamps shall be of clustered LED type.

All fascia enunciated points shall be suitable to accept external contacts of either ‘NO’ or ‘NC’ self or hand reset type for initiating the annunciation sequence shall be suitable for accepting fleeting faults of duration as less as 15 milliseconds.

For static annunciator schemes, special precaution shall be taken by the contractor to ensure that spurious alarm conditions do not appear due to influence of external magnetic fields on the

annunciator wiring and switching disturbances from the neighbouring circuits within the panels / desks.

A “Lamp Test” push button shall be provided for each individual panel’s group of annunciators to limit the sudden drain on the battery. Provision of testing facilities for flasher and audible electronics alarm circuits of annunciators is desirable. The Contractor shall give the details of the offered scheme.

Annunciator shall have following features:

- Suitable for annunciating subsequent faults immediately after the sound cancel of the previous fault.
- During lamp test, if a fault occurs, the corresponding lamp circuit shall be automatically disconnected from the “lamp test” circuit and shall start flashing.
- Designed to prevent mal-operation of the scheme or sequence when the push buttons are pressed incorrectly or in the wrong order.
- "Alarm Supply Failure” Alarm scheme similar to the normal annunciation sequence but shall operate on a different DC supply or on AC auxiliary supply.
- Alarm annunciates having provision to integrate all alarm / trip signals to PLC.
- Alarm annunciation shall be provided for transformers, Chlorination system and surge vessel system where ever discrete local automation shall be envisaged.
- All Annunciations shall have interfacing facilities with communication for SCADA.

6.4.9 Indicating Instruments & Meters

The instruments shall be electronic / digital type with LCD display. These instruments should have high performance ratio and can be equipped with digital output (for alarms) or with interfacing facilities for communication and remote reading of parameters.

- **Metering Instruments**
- Multi-Function Meter with the facility to measure A, V, KW, KWh, KVAr, PF, KVARh, Hz and Hormonic (%THD) contents with communication port.
- Multi-Function Meters shall be of the accuracy class 1.0, suitable for measurement of unbalanced loads in three phase three wire circuits.
- MFM shall be suitable for operation from the secondary of CTs and VTs. They shall be provided with a separate 3 phase 4 wire type test blocks for the testing of the meters without disturbing the CT and VT secondary connections.

The instruments can be electronic / digital type with LCD display& RS 485 connectivity for remote reading of parameters in SCADA. These instruments should have high performance ratio and can be equipped with digital output (for alarms).

6.4.10 Control and Selector Switches

Control and instrument switches shall be heavy duty rotary type, provided with escutcheon plates clearly marked to show operating position and suitable for semi-flush mounting with only the switch front plate and operating handle projecting out. The connections shall be from the back. The contact assembly at the back of the switch shall be enclosed in dust tight removable covers.

The control switches shall be 3 positions, spring return to neutral type. They shall be provided with contacts to close in ‘normal after close’ and ‘normal after trip’ position. Each switch shall have external red and green indicating lamps, (except when discrepancy type switches are called for). In

addition, a semaphore indicator shall be provided for earthing switch. Local / Off / Remote selector switch shall be stay put 2 / 3 position with lockable provision.

Contacts of the switches shall be spring assisted and contact faces shall be of silver / silver alloy. Springs shall not be used as current carrying parts. Contact rating and configurations of the switches shall be adequate for the functions desired.

Lockable type switches, which can be locked in a particular position, shall be provided, if required. Emergency stop buttons, if any, shall incorporate 'stay-put' features with independent reset facilities.

6.4.11 Indicating Lights / Pilot Lights

Indicating light shall be rated for operation at either 230V AC or at the specified DC system voltage as applicable. Lights shall be provided with translucent light covers.

Clustered LED type lamps shall be provided. Lenses shall be glass or plastic in standard colours, red, green, blue, white and amber, in accordance with IEC 60073.Miniature pilot lamps may be provided with plastic marking plate contained inside square (or rectangular) front lens to provide indication of legend or symbols engraved on the marking plate.

The basis of colors shall be as follows:
Red : Flow of energy.
Green : No flow of energy.
White : Supervision of power available, relay coil healthy, etc.
Amber : For all alarm conditions such as pressure low, overload, Disagreement with original condition, 'abnormal' condition or 'sequence - on' condition also for service and test position.
Blue : For all healthy conditions such as control supply, spring charged and lockout relay coil healthy.
Yellow : For R, Y, B indication light, yellow as one of the lights.

6.4.12 Push Buttons

Push buttons shall be of momentary contact type with rear terminal connections. The colour of the push button actuator shall be red for 'OPEN / STOP' and green for 'CLOSE / START'. The push button knob shall be suitably shrouded to prevent inadvertent operation. The push buttons shall be provided with integral inscription plates engraved with their designation.

Normal stop push button shall be mushroom type latch able in red colour, after pressing and it shall be latched, and latch can be removed by clockwise rotation (Motor stops automatically after predetermined conditions such as delivery valve close in case of pumps). This may replace stop push button.

Emergency stop push button red in colour shall be lockable by pressing the push button and can be opening only with key and with shrouding. (Motor stopped immediately irrespective of predetermined conditions required)Emergency Push button with shrouding shall be provided near transformer and motors for remote tripping.

Reset push button shall be either for resetting the flag and OLR or LEDs with push button for resetting.

All push buttons shall have independent, potential free, 2NO + 2NC contacts. The contact faces shall be of silver / silver alloy. The contacts shall be rated 10A and capable of breaking inductive load of 5A at 110V DC.

All push button shall have additional NO/NC potential free for hard wiring to instrumentation control panel.

6.4.13 Space Heaters

Adequately rated anti-condensation space heaters shall be provided for each switchboard / cubicle, bus ducts and Motors above 7.5kW. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240V, 1 phase, 50Hz, AC system.

Space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a RTD thermostat to cut off the heaters at 35 degree C.

6.4.14 Cubicle Lighting / Receptacle

Each cubicle shall be provided with interior lighting by means of 18 W energy efficient (lumen per watt shall be indicated) fluorescent tube lighting fixture. An MCB shall be provided for the lighting circuit. The lighting fixture shall be suitable for operation from a 240V, 1ph, 50 Hz, AC supply. A 240V, 1phase, AC receptacle (socket) plug point shall be provided in the interior of each panel with an MCB.

6.4.15 Power and Control Cable Termination

Terminals for power connections shall be complete with adequate phase segregating insulating barriers, shrouds and suitable aluminium solder less crimping type of lugs for terminating the cables and control cables lugs and ferrules shall be tinned copper confirming to IS 8309. The cable lugs for control cables shall be provided with insulating sleeve and shall suit the type of termination provide on the equipment.

Double compression type glands with armour and bonding clamps for the termination of all solid dielectric multicore cables shall be provided and shall confirm to BS:6121. They shall be designed to secure the armour wires to provide electrical continuity between the armour and the threaded fixing component of the gland and to provide watertight seals between the cable outer sheath and gland and between the inner sheath and threaded fixing component. The gland shall preferably project above the gland plate(non-magnetic material) to avoid entry of moisture.

Earthing connectors between cable armour and earth shall be routed outside the cable gland in an approved manner. Gland insulation shall be capable of withstanding test for appropriate high voltage for one minute.

Cable terminations for HV / MV cables shall be heat / cold shrinkable type. Adequately sized shrouds / bolts shall be provided at connections to completely cover the terminations.

Where core balance type current transformers are provided on the feeder cables for earth fault protection, glands for cables shall be insulated from earth in an approved manner.

6.4.16 Wiring for Control and Protective Circuits

All low voltage wiring for control, protection and indication circuits shall be carried out with 1100V grade, PVC insulated cable with stranded, tinned copper conductor of minimum 1.5sq.mm size. The size of conductor for CT circuits shall be minimum 2.5sq. mm.

All wiring shall be run on the sides of panels and shall be neatly bunched and cleated without affecting access to equipment mounted in the panel. The wiring shall be bound and supported by clamping, roughing or lacing. Spiral wrapping shall not be accepted. Wireways shall not be more than 50% full. Adequate slack wire shall be provided to allow for one re-stripping and reconnection at the end of each wire. When screened cables or wires are necessary, an insulating sheath shall be included. Wiring and supports shall be of fire-resistant material.

Wiring shall only be jointed or tied at terminals. Terminals of the clamp type shall not have more than two wires connected.

6.4.17 Termination and Ferrules

Engraved core identification ferrules, marked to correspond with the wiring diagram, shall be fitted to each wire and each core of multicore cables terminated on the panels.

Moisture and oil resisting insulating material shall be used. The ferrules shall be of the interlocking type and shall grip the insulation firmly without falling off when the wire shall be removed.

All wires forming part of a tripping circuit shall be distinctively marked. Spare auxiliary contacts of electrical equipment shall be wired to terminal blocks.

6.4.18 Control Wiring Terminal Blocks

Terminal blocks shall be of 1000V grade, 10A and stud type. Brass stud of at least 6 mm dia. with fine threads shall be used and securely locked within the mounting base to prevent turning. Each terminal shall comprise two threaded studs, with a link between them, washers, and matching nuts and locknuts for each stud. Connections to the terminals shall be at the front.

Terminals shall be numbered for identification, grouped according to function. Engraved ‘black on-white’ labels shall be provided on the terminal blocks describing the function of the circuit.

Terminals for circuits with voltage exceeding 110V shall be shrouded. Terminal blocks at different voltages shall be segregated into groups and distinctively labelled. Terminals used for connecting current transformer secondary leads shall be ‘disconnecting and shorting’ type with a facility for earthing the secondary.

Terminal blocks shall be arranged with 100 mm clearance, between any two sets. Separate terminal stems shall be provided for internal and external wiring respectively. All wiring shall be terminated on terminal blocks, using crimping type lugs or claw type of terminations.

At least 20% cores shall be kept spare in multicore control cables. At least 10% spare terminals shall be provided and space for adding another 10% spares terminals shall also available in each set of TBs.

6.4.19 Bus Bars

The Bus bars shall be of electrical grade, high conductivity, copper and shall be provided with minimum clearances as per relevant IS. Bus bar cross section shall be uniform throughout the length of the switchgear. All busbars and bus taps shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

The insulation shall be non-inflammable and self-extinguishing type and in fast colours to indicate phases. The dielectric strength and properties shall hold good for the temperature range of 0 to 95 degree centigrade. If the insulating sleeve is not colour, bus bars shall be colour coded with colour PVC tape at suitable intervals for easy identification.

Busbar joints shall be of the bolted type. Spring washers shall be provided to ensure good contact at the joints. Busbars shall be thoroughly cleaned at the joints and suitable contact grease shall be applied just before making a joint. Direct access to, or accidental contact with busbars and primary connections shall not be possible.

All apertures and slots shall be protected by baffles to prevent accidental shorting of busbars due to insertion of maintenance tools.

Sequence of red, yellow and blue phases and neutral for four-pole equipment shall be left to right and top to bottom, for horizontal and vertical layouts respectively.

End terminations at transformer end and MV panel end shall be flexible bus bar such that no load / force / weight of the bus bar act on the terminal studs.

6.4.20 Current & Voltage Transformers

Current transformers shall be of cast resin, bar primary type unless specified otherwise, suitable for continuous operation at the ambient temperature prevailing inside the switchgear enclosure and shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block. The class of insulation shall be Class E or better.

Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear. For wound primary type CTs, the short time current rating shall not be less than 0.5 sec. CT core laminations shall be of high-grade silicon steel. Where multi ratio current transformers are specified, a label shall be provided, clearly indicating the connections required for the alternative ratios.

These connections shall also be shown on panel wiring diagrams. Identification labels shall be fitted giving type, ratio, rating, output and serial numbers and duplicate rating labels are to be fitted on the exterior of the mounting chambers suitably located to enable reading without the removal of any cover or metal sheeting forming part of the structure of the switchboard.

Magnetization characteristics, calculated performance and protective settings shall be provided by the contractor. All Voltage Transformers shall be of Single-Phase type. The bus VT's shall be housed in a separate panel in a truck so as to be fully with drawable. All Voltage transformers shall have HRC fuses/MCBs on Primary and MCBs on Secondary Side. There shall be provision for changeover on secondary side of Voltage Transformers to have alternate arrangement in case one Voltage Transformer fails.

6.4.21 Relays

(a) All Protective relays shall be numerical type except aux. relays. Numerical relays shall have appropriate setting ranges, accuracy, resetting ratio, transient overreach and other characteristics to provide required sensitivity.

(b) All numerical protective relays shall be flush mounted at the front with connections at the rear. Shall have communication port for remote, metering and monitoring facility, suitable for electrical measurement including voltage, current, power (active / reactive) and energy parameters.

(c) All numerical relays shall have keypad to allow relay settings from relay front. Resetting knobs shall be accessible from the front on removing the external cover and shall be external to the case.

(d) All numerical relays and timers shall be rated for control supply voltage specified and be capable of satisfactory continuous operation between 70 % and 110 % of the rated voltage. Making, Carrying and Breaking Current ratings of the relay contacts shall be adequate for the circuits in which they are used.

(e) The numerical relays shall have communication, metering and monitoring facility. The communication facility shall have two Ports local front port(RJ45/USB) for laptop communication and the second portRear RS485for SCADA.

(f) The numerical processor shall be capable of measuring and sharing values of a wide range of quantities, events, faults and disturbance recordings with time stamping using internal real time clock. Battery backup for real time clock in the event of power failure shall be provided.

(g) Numerical Relays shall have diagnostic feature with self-check for power failure, Programmable routines, memory and main CPU Failures etc.

(h) The Protective relays shall have adequate number of potential free contacts (Programmable). The Contacts shall be suitable for directly wiring in the breaker closing and tripping circuits operating from 110V DC Control Voltage.

(i) The current operated relays shall have provision for 4 Sets of CT Inputs and Voltage operated relays shall have provision for 3 PT inputs. Relays shall be suitable for CT secondary current suitable for CT Secondary current of 1A / 5A selectable at Site.

(j) Numerical Relays shall be immune to any kind of electromagnetic interference and capacitance effect due to length of connected control cables.

(k) Timer function shall be programmable for ON/OFF delays.

(l) Numerical Relays shall be able to provide supervisory function such as trip circuit monitoring, circuit breaker monitoring, PT & CT supervisions and recording facilities with post fault analysis.

(m) All relays shall withstand minimum test voltage of 2kV AC RMS for one minute.

(n) Numerical relays shall have two level password protections, one for read only and other for authorization for modifying the setting etc.

6.4.22 Energy monitoring and power supply management

Necessary Provisions & features shall be incorporated to enable energy monitoring / energy management for the installation. Energy Metering shall meet the requirement of guaranteed specific energy consumption specified by the contractor through instrumentation control system.

In case, Numerical relays having built in features of energy measurement of requisite accuracy and provided in switch gear, separate energy meter shall not be required.

Necessary provision & features shall be incorporated to under voltage monitoring / relay for incomer feeder, busbar chamber and control supply.

6.4.23 I/O signal for Instrumentation, Control & Automation System from Electrical panels.

I/O signals from instruments shall be separately wired to a marshalling box such that instrumentation engineers shall not enter in to power panel that are not familiar with them.

Necessary provisions shall be incorporated to meet the requirements indicated in:
(a) I/O Schedules – ACB/VCB, Command Open &Close, Feedback trip, Breaker healthy(Ready to close), Local /Off/Remote, Breaker Opened / Closed, Breaker Test/Service Position.
(b) Data Transfer Schedule
(c) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System,Part-13, and Volume 2 of the Bid document.

6.4.24 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.5 415V Metal Enclosed Switchgears (PCC / MCC)

415V Metal Enclosed Switch gear (PCC / MCC) system shall have provision such that inter-opera ability with instrumentation controls system. MCC/ PCC panel boards shall be offered for final inspection at the OEM's works with routine tests.

6.5.1 Applicable Standards

The switchgear and components shall conform to the latest applicable standards specified below.

Switchgear General Requirements	IS:13947/BS:5486/IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages upto and including 1000V AC & 1200V DC	IS:8623/BS:5486/IEC:61439-1
Air Circuit Breakers (ACB)	IS:13947-Part (1 & 2) /BSEN:60947 /IEC:60947
Low-voltage Switchgear and Control gear assemblies	IEC:61439 – 1 &2
Moulded Case Circuit Breaker	IS:2516 / IEC 60947-2/ BSEN:60947-2/ IS:13947 –Part (1 &2)
Miniature Circuit Breakers	IS:8828/BSEN:60898
Low voltage Fuses	IS:13703/BS:1362/IEC:60269-1
Contactors	IS:13947/BS EN60947-4 /IEC:60947-1
Starters	IS:13947/BS EN60947 – 4/ IEC:60292-1 to 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Current Transformers	IS:2705/BS:7626
Voltage Transformers	IS:3156/BS:7625/IEC:60044, 60186
Indicating instruments	IS:1248/BS:89/IEC:60051

Electrical relays.	IEC:60255
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530/BS:5685 / IEC:60145,60211
Degree of Protection	IS:13947/IEC:60947-P1
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphating coated iron and steel	IS:6005/BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS:5572
Guide for Selection of Electrical Equipment for Hazardous areas	IS:5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC:60079
Basic and Safety Principles for Man-Machine Interface, Marking and Identification - Coding Principles for Indicators and Actuators.	IEC:60073
Conductors of Insulated Cables.	IEC:60228
Dimensions of low-voltage switchgear and Control gear. Standardized mounting on rails for mechanical support of electrical devices in switchgear and Control gear installations.	IEC 60715
Graphical symbols for use on equipment.	IEC:60417
Electricity metering equipment	IEC:62052-11 / IEC 62052-21
Empty enclosures for low-voltage switchgear and Control gear assemblies General requirements and Control gear assemblies General Requirements	IEC:62208

6.5.2 General

The LV switch boards shall be type tested assemblies (TTA Panels) in all respects be suitable for operations in service conditions and withstanding the stresses to the seismic conditions. The offered design shall meet the requirements of IEC 60068-2-57, & IEC 60068-3-3. Necessary type pest report from an independent internationally accredited test laboratory shall be furnished to establish that the offered design performs satisfactorily in compliance to the reference standards.

The LV switchboards shall be type tested assemblies (TTA) fully meeting the requirements of IEC 61439 – 1&2 for design verified assemblies. The eligible switchboard suppliers shall be Original Equipment Manufacturer (OEM) only with their own range of ACBs, MCCBs, Power Contactors & other switchgear devices. The switchboards shall be manufactured, design & tested by OEM at their own works.

The LV main switchboards and the associated equipment, including switchgear, control gear and bus bar assemblies shall be certified for the category of duty specified. The LV Main Switch board shall be identical in mechanical construction to the LV Switch board which had been type-tested by an acceptable, multi fold design for structural members (9-fold design) with impact test as per IEC62262, accredited and independent testing laboratory for the fault conditions, temperature rise limits. Any manufacture not having the above will not be considered for supply. The main circuits of the LV main switch boards shall have an insulation voltage of 1000VAC. Panels shall be tested to withstand internal arc fault of 50KA, 0.4 seconds and valid Type Test Certification shall be provided as per IEC61641.

The design temperature for the equipment provided in the main low voltage switch boards shall be+ 45^0 C. The relative humidity shall be75% at a temperature of + 45 ^{o}C.

Where armoured multicore cables terminate inside the switch board enclosure, glanding plates or glanding brackets shall be provided for securing the cables to the switchboard. Glanding plates, glanding brackets and extension boxes shall be removable and shall be of adequate size for the particular cables to be terminated. Separate current transformers shall be provided for each protection device and for instrumentation. The switch gear assembly/sub-assemblies or panels shall be termite and rodent proof. The sub-assemblies of similar equipment shall be interchangeable.

Switchboards (TTA) shall also have Seismic withstand capability.

The offered switch board along with Incomer ACBs / MCCBs and outgoing feeders with all interconnections shall be as per type tested design of OEM at CPRI/ERDA/Independent international test house for short circuit, temperature rise, protective earth short circuit test and dielectric tests of the ratings required.

For operator safety IP2X (touch proof) protection to be available even after opening the feeder compartment door. The compartmentalization to be achieved by using metal or FRP separators, use of PVC sheet /Xylem sheets shall not be allowed.

The Switch boards shall be of adequate size with a provision of spare space to accommodate possible future additional switchgear.

Features of Constructions

(a) The switchgear shall be metal enclosed, dust proof, modular type, suitable for indoor floor mounting and shall have following features:

(i) Total height of switchgear shall not exceed 2300 mm. Height of Switches, pushbuttons shall not exceed 1800 mm and shall not be less than 600 mm.

(ii) Shall be single front execution and fixed type.

(iii) Shall have designation labels both on front and rear sides.

(iv) Shall be provided with proper gasketing for removable covers, doors, between panels and base frame and all around the perimeter of adjacent panels.

(v) Degree of Protection shall be IP54 for indoor & IP65 for Outdoor.

(vi) Thickness of CRCA Sheet the panel doors shall be 2.5 mm or over and for the rest shall be 2.0mm.

(vii) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

(viii) Shall follow IS 5572 /IEC 60079, standard specification and standard practice for installation in Hazardous area.

(b) Switchgear shall be divided into distinct vertical sections each comprising:

(i) A completely enclosed busbar compartment running horizontally.

(ii) Enclosed vertical busbars serving all modules in vertical section.
(iii) A separate horizontal enclosure for all auxiliary power and control buses, if required.
(iv) Vertical cable alley of 250mm wide covering entire height.
(c) Operating devices shall be incorporated only in the front of switchgear.
(d) Each shipping section shall have metal sheets at both ends.
(e) Cable alley shall be provided with suitable hinged doors.
(f) GS Earth bus of size 50mm x 10 mm shall be provided at the bottom.
(g) All doors shall be with concealed type hinges and captive screws.
(h) Each vertical section shall be equipped with 240V, 1Phase, 50Hz space heater controlled by thermostat.
(i) A 240V, Phase, AC plug point shall be provided in the interior of each cubicle with on-off switch for correction of head lamps.
(j) 20% spare feeders with at least one for each type of highest rating shall be provided in each switchgear.
(k) Interchangeability
All identical equipment and corresponding parts be fully interchangeable without any modifications.
(l) Main and Auxiliary Buses
(i) Switchgear busbars shall be of uniform cross section throughout the length and made of high conductivity, electrical grade hard drawn copper conductor with 1.40Amp/Sq.mm current density throughout the length.
(ii) All busbars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.
(iii) Busbar joints shall be provided with contact grease at the joints and shall be complete with tensile steel bolts and belleville washers and nuts.
(iv) All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate coated Iron and Steel”. Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.
(v) After phosphate coated, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests. The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 120 microns.
(vi) Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.
(vii) A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.
(m) The equipment shall be arranged within each compartment such that all normal maintenance can be carried out through hinged access doors or removable covers, and where possible from the front. The switch board shall have a rated short time withstand current as per SLD and a fault with stand for a supply voltage of (415V) AC between phases at 50Hz.
(n) Protection against shock in normal service shall be achieved by the provision of barriers or enclosures both vertical and horizontal and between adjacent units to ensure segregation and prevent accidental contact with live parts, or by complete insulation of all live parts. Control cables shall be segregated from primary conductors.

(o) Switch boards construction shall employ the principle of compartmentalized and segregation for each circuit.

(p) Incomer and bus section anelsor sections shall be separate and independent and shall not be wired with sections required for feeder

(q) Switch board shall be readily extensible on both sides by addition of vertical sections after removal of the end covers.

(r) Special care to be taken to ensure effective earthing of the frame and doors of the switchboards. All metallic parts shall be effectively connected a protective earth system in the switchboard to ensure positive earthing at all times.

(s) All panels and covers shall be properly fitted and square with the frame. The holes in the panel shall be correctly positioned.

(t) Switchboard shall be provided with "Danger Notice Plate" conforming to relevant Indian Standards.

(u) The LVSBs shall be mounted on a robust base frame made up of steel channels with a minimum height of 100mm. The base frame shall be able to withstand the static and dynamic loads of the LVSBs. The steel channels shall be painted with epoxy polyster paint.

(v) For compartmentalized switchboards, separate totally enclosed compartments shall be provided for horizontal busbars, vertical busbars, ACBs, MCCBs, and cable alloys.

(w) Cable compartments shall be of adequate size for easy termination of all incoming and outgoing cables entering from bottom or top. The construction shall include necessary and adequate and proper support shall be provided in cable compartments to support and clamping the cable in the cable alley/cable chamber.

6.5.3 Air Circuit Breaker (ACB)

(a) Air circuit breaker shall be selected for feeders for load current equal to and more than 630A.

(b) Circuit breakers shall be operated by a motor spring charging type of mechanism. The motor operated spring charged mechanism shall be complete with motor, opening spring, closing spring and all accessories to make the mechanism a complete operating unit.

(c) The tripping spring shall be charged by the closing action, to enable quick tripping. Closing of the circuit breaker shall automatically initiate recharging of the springs to enable the mechanism to be ready for the next closing stroke. Charging time for the springs shall not exceed 30 seconds. It shall be possible to manually charge the springs in an emergency.

(d) Transfer from motor to manual charging shall automatically disconnect the charging motor. The charging mechanism shall be provided with mechanical indicators to show "charged" and "discharged" conditions of the spring. Failure of any spring, vibration or mechanical shock shall not cause tripping or closing of the circuit breaker.

(e) Only one closing operation of the circuit breaker shall result from each closing impulse (manual or electrical), even if the breaker trips while the control device (manual or electrical) is being held in the "close" position.

(f) The circuit breaker mechanism shall make one complete closing operation, once the push button has been operated and the first device in the control scheme has responded, even though the PB shall be released before the closing operation shall be completed, subject to the condition that there is no counter-impulse for tripping.

(g) Means shall be provided to manually open and close the breakers slowly, when the operating power shall not be available, for maintenance and adjustments. A local manual trip device shall be provided on the operating mechanism.

(h) All operating mechanisms shall be provided with "ON" - "OFF"- "TRIP" mechanical indication.

(i) Closing coils and other auxiliary devices shall operate satisfactorily at all voltages between 85-110% of the control voltage. Trip coils shall operate satisfactorily between 70 -110% the rated control voltage.
(j) The ACB shall be 4 pole with modular construction, drawout, manually operated. In case of 4 pole version neutral rating shall be 100% of phase.
(k) The Breaker shall be provided with Microprocessor based Protection unit for Inverse-time delayed overload releases for the phases, Short-time delayed short-circuit releases and earth-fault releases.
(l) The breaker service Short Circuit breaking capacity (I_{CS}) shall be equal to ultimate Short Circuit capacity (I_{CU}) and shall be equal to short time withstand current of Breaker (I_{CW}).
(m) ACB shall be provided for Incoming side of the PCC/MCC from transformer irrespective of rating of feeder.
(n) The cradle shall be so designed and constructed as to permit smooth withdrawal and insertion of the breaker into it. The movements shall be free from jerks, easy to operate and shall be on steel balls/rollers and not on flat surfaces.
(o) There shall be provision for locking the breaker in any of Service, Test or Isolated positions.
(p) ACB shall be supplied with 4 auxiliary contacts (combinations of NO / NC shall be selected at site) and 1 trip contact. If need arise there shall be facility to add additional auxiliary contacts (6 no's).
(q) ACB shall have provision to use `Ready to Close' contact.
(r) The safety shutter shall prevent inadvertent contact with isolating contacts when breaker is withdrawn from the Cradle.
(s) Arc Chute covers wherever necessary shall be provided.
(t) ACB shall have a Ready to close indication contact which shall be used to give a single indication via indicating lamps on panel door if ACB is ready to be closed, after checking all the given conditions ensuring safety for user and electrical distribution.

6.5.4 Motor Protection Relay

Motor protection including phase failure detection, adjustable motor protection for stalled motors during startup or normal operation, configurable current limits to generate trips or warnings with following features:
(a) Overload classes.
(b) Thermistor motor protection (PTC).
(c) Earth fault detection.
(d) Power and voltage-based protection functions.

6.5.5 Moulded Case Circuit Breaker (MCCB)

All MCCB's shall be of the air break, quick make, quick break and trip free type switching mechanism, arc extinguishing device and the tripping unit shall be contained in a compact, high strength, heat resistant, flame retardant, insulating moulded case with high withstand capability against thermal and mechanical stresses. All MCCB's shall be capable of Variable overload adjustment.

MCCBs shall have an ultimate short circuit capacity not less than the short circuit current Specified. MCCBs shall have a service short circuit breaking capacity (I_{CS}) is equal to the ultimate short-circuit capacity (I_{CU}).

Each pole of MCCB shall be fitted with a bi-metallic thermal element for inverse time delay protection and a magnetic element for short circuit protection. Alternatively, they shall be fitted with a solid-state protection system. Such a protection system shall be fully self-contained, needing no separate power supply to operate the circuit breaker tripping mechanism.

Thermal element shall be adjustable. Adjustments shall be made simultaneously on all poles from a common facility. Thermal elements shall be ambient temperature compensated.

Electronic/Microprocessor Trip Unit shall be equipped with internal battery to power the display in no load conditions.

The MCCBs shall be provided with the following features:
- Common trip bar for simultaneous tripping of all poles.
- Shrouded terminals.
- Time for clearing short circuit current of 20 msec.
- 2 NO + 2 NC auxiliary contacts suitable for switching 24V DC, 10mA PLC Signals with no loss of signal integrity.

MCCBs shall be actuated by an extended rotary-handle with pad lock arrangement that clearly indicates the three distinctive positions: ON, OFF and TRIPPED.

Adjustable overload releases for the phases, Adjustable Short-time delayed short-circuit releases and earth-fault releases. Rotary operated mechanism 240V AC Shunt trip Coil has to be provided. Manually closing mechanism should be accommodated in a Moulded housing of robust and vermin-proof construction.

MCCB shall be provided with double insulation (insulation between front cover and internal power circuits to avoid any accidental contact with live current carrying path with the front cover open). The insulating case shall be made of high strength heat resistant and flame retardant thermosetting insulating material.

6.5.6 Switches

415V air-break switched shall be of the load break, fault make, group operated type. For use on 3-phase systems, the switches shall be of the triple pole type with a link for neutral wire. For use on single phase system, the MCB type switches shall be of the two-pole type.

(a) Switches shall be of the heavy duty, quick make and quick break type. Switch contacts shall be silver plated, and contract springs shall be of stainless steel. Switch handles shall have provision for locking in both fully open and fully closed positions. Mechanical ON-OFF indication shall be provided on the switches.

(b) Switches for controlling motor circuits shall be of the load break, fault make type, and shall be capable of breaking locked rotor current of the associated motor.

(c) 415V switches and fuses shall be provided with the following interlocks so that.

(d) The fuses are not advisable unless the switch shall be in fully open condition.

(e) It shall not be possible to close the switch when the cover shall be open, but an authorized person may override the interlock and operate the switch. After such an operation, the cover shall be prevented from closing if the switch shall be left in the 'ON' position.

(f) Fuse less system shall be provided in case fuses required, fuses shall be of the HRC cartridge type, mounted on plug-in type of fuse bases. Fuses shall be provided with visible indicators to show that they have operated.

(g) Earthing and neutral lines in main supply circuits shall be of solid silver-plated copper and be of the bolted pattern.
(h) Fuses and links functionally associated with the same circuit shall be mounted side by side.

6.5.7 Miniature Circuit Breaker (MCB)

MCB shall be hand operated, air break, quick make, quick break type. Operating mechanisms shall be mechanically trip-free from the operating knob to prevent the contacts being held closed under overload or short-circuit conditions.

Each pole shall be fitted with a bi-metallic element for overload protection and a magnetic element for short-circuit protection. Multiple pole MCBs shall be mechanically linked such that tripping of one pole simultaneously trips all the other poles. The magnetic element tripping current classification shall be of the type suitable for the connected load. Where this shall not be specified, it shall be Type C. The short circuit rating shall be not less than that of the system to which they are connected.

6.5.8 Contactors

The power contactors used in the switchboard shall be of, air break, single throw, triple pole, electromagnetic type. Contactors shall be suitable for uninterrupted duty and rated for Class AC3 duty in accordance with the latest edition of IS 13947.

Operating coils of all contactors shall be suitable for operation on 240V, single phase, 50Hz supply. Contactors shall be provided with at least two pairs of NO and NC auxiliary contacts. Contactors shall not drop out at voltages down to 70% of coil rated voltage. Contactors shall be provided with a three element, positive acting, ambient temperature compensated, time lagged, hand reset type thermal overload relay with adjustable settings. The hand reset button shall be flush with the front door of the control module and shall be suitable for resetting the overload relay with the module door closed. Relays shall be either direct connected or CT operated. Overload relay and reset button shall be independent of the "Start" and "Stop" push buttons. All contactor shall all be provided with single phasing preventer (SPP).

Motor starters shall be complete with auxiliary energy meters, protective relays, timers and necessary indications such that inter-operability with the instrumentation system.

6.5.9 Current Transformers / CBCT

(a) Current Transformers shall be Cast Resin type.
(b) Current transformers shall have polarity markings indelibly marked on each transformer and at the lead terminations at the associated terminal block.
(c) Current transformers shall be able to withstand the thermal and mechanical stresses resulting from the maximum short circuit and momentary duties of the switchgear, as indicated in the Technical Specification.
(d) CT core laminations shall be of high-grade silicon steel.
(e) Identification labels shall be fitted giving type, ratio, rating, output and serial numbers.

6.5.10 Indicating Instruments & Meters

All indication instruments and watt hour meters shall be of the digital type and shall have an accuracy of Class 1.0. Digital type ammeters, voltmeters and multifunction energy meters shall have communication port RS485.

6.5.11 Indicating Lights

Indicating lights shall be of the cluster LED type, with low watt consumption. Indicating lamp shall be rated for operation at either 240V AC or at the specified DC system voltage as applicable. LED shall be provided with translucent lamp covers. Bulbs and lenses shall be interchangeable and easily replaceable from the front.

6.5.12 Push Buttons

"Start" and "Stop" push buttons shall be coloured green and red respectively. Stop Push Button shall be lockable stay-put type with Mushroom head without key or Emergency push button lockable in OFF position and open able only with key.

6.5.13 Space Heaters

Adequately rated anti-condensation space heaters shall be provided, one for each control panel, for each switchboard and for each marshalling kiosk. Space heater shall be of the industrial strip continuous duty type, rated for operation on a 240V, 1phase, 50Hz, AC system. Each space heater shall be provided with a single pole MCB with overload and short circuit release, a neutral link and a control RTD thermostat to cut off the heaters at 35Deg. C.

6.5.14 Safety Arrangements

All terminals, connections and other components, which may be “live” when front access door shall be open, shall be adequately screened. It shall not be possible to obtain access to an adjacent cubicle or module when any door shall be opened. Components within the cubicles shall be labelled to facilitate testing.

6.5.15 Earthing of Switchboards / Panels

Each switchboard, control panel, etc. shall be provided with an earth busbar running along its entire length. The earth bus bar shall be located at the bottom of the board/panel.

Earth bus bars shall be of copper and shall be rated to carry the rated symmetrical short circuit current of the associated board/panel for one second, unless otherwise specified. Earth bus bars shall be properly supported to withstand stresses induced by the momentary short circuit current of value equal to the momentary short circuit rating of the associated switchboard/panel.

Positive connection of the frames of all the equipment mounted in the switchboard to the earth bus bar shall be maintained through insulated conductors of size equal to the earth bus bar or the load current carrying conductor, whichever is smaller.

All instrument and relay cases shall be connected to earth bus bar by means of 1100V grade, green coloured, PVC insulated, stranded, tinned copper, 2.5 sq. mm conductor looped through the case earth terminals.

6.5.16 Internal Wiring

The internal wiring shall be carried out with 650 / 1100V grade, PVC insulated, stranded conductor wires. The minimum size of conductor for power circuits shall be 4 Sq.mm copper conductor. Control circuits shall be wired with copper conductor of atleast 1.5 Sq.mm.

6.5.17 I/O for Instrumentation, Control & Automation System from Electrical panels.

I/O signals from instruments shall be wired to marshalling box of MCC / Switch gear such that instrumentation engineers shall not enter into power system panel that are not familiar with them. Necessary provisions shall be incorporated to meet the requirements indicated in:
(a) I/O Schedules – ACB/VCB, Command Open & Close, Feedback trip, Breaker healthy (Ready to close), Local /Off/Remote, Breaker Opened / Closed, Beaker Test/Service position feedback.
(b) Data Transfer Schedule.
(c) Alarm Schedule of Particular requirement of Instrumentation, Control & Automation System, Part-13, and Volume 2 of the Bid document.

6.5.18 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc. shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.6 Power capacitor and APFC control panel (415V)

6.6.1 Applicable Standards

The capacitor and control panel conform to the latest applicable standards specified below. In case of conflict between standards and this specification, this specification shall govern.

Reference standards	IS: 13585
Shunt capacitors for power systems	IS: 13340
Internal fuses and internal overpressure disconnections for shunt capacitors	IS: 12672
Metal enclosed switchgear	IS: 3427 / BSEN 60298 / IEC: 60298
Code of practice for phosphate coated iron and steel	IS: 6005/BS: 3189
Specification for copper rods and bars for electrical purpose	IS: 613

6.6.2 Design Features

(a) The capacitor banks shall be complete with all parts that are necessary or essential for efficient operation. Such parts shall be deemed to be within the scope of supply whether specifically mentioned or not.
(b) The capacitor bank shall be complete with the required capacitors along with the supporting post insulators, steel rack assembly, copper bus bars, copper connecting strips, foundation channels, fuses, fuse clips, etc. The steel rack assembly shall be hot dip galvanized.
(c) The capacitor bank may comprise of suitable number of single-phase units in series parallel combination. However, the number of parallel units in each of the series racks shall be such that failure of one unit shall not create an overvoltage on the units in parallel with it, which shall result in the failure of the parallel units.
(d) The complete capacitor banks with its accessories shall be metal enclosed (in sheet steel cubicle), indoor floor mounting and free-standing type.
(e) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

(f) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate coated and then painted with two coats of zinc rich primer paint. After application of primer, two coats of finishing synthetic enamel paint oven baked/stove shall be applied.

(g) The assembly of the banks shall be such that it provides sufficient ventilation for each unit. Necessary exhaust fan, louvers with filters must be provided in the cubicle to ensure proper ventilation for heat dissipation.

(h) Each panel shall be provided with 240 Volts, 1 phase, 50Hz, 5amps, 3pin receptacles with switch located in a convenient position. An interior illuminating CFL / LED lamp together with the operating door switch and protective fuses shall be provided.

(i) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute in accordance with the provisions of the latest edition of IS: 2834.

(j) Capacitors shall be of Mixed Dielectric of polypropylene and paper with internal element fuses. The impregnate shall be non-PCB (poly chlorinated biphenyl) oil.

(k) Each unit shall satisfactorily operate at 135% of rated KVAR including factors of overvoltage, harmonic currents and manufacturing tolerance. The units shall be capable of continuously withstanding satisfactorily any overvoltage upto a maximum of 10% above the rated voltage, excluding transients.

(l) Each capacitor unit/bank shall be fitted with directly connected continuously rated, low loss discharge device to discharge the capacitors to reduce the voltage to 50 volts within one minute upon disconnection, in accordance with the provisions of the latest edition of IS:2834.

(m) APFCR panel shall have suitable detuned reactors for harmonic filtration in case of PMCC connected with VFD or Soft Starters.

(n) The PFC system shall be provided to achieve a power factor of not less than 0.98.

(o) Unit Protection

Each capacitor unit shall be individually protected by an HRC fuse suitably rated for load current and interrupting capacity, so that a faulty capacitor unit shall be disconnected by the fuse without causing the bank to be disconnected. Thus, the fuse shall disconnect only the faulty unit and shall leave the rest of the units undisturbed. An operated fuse shall give visual indication so that it may be detected during periodic inspection. The fuse braking time shall co-ordinate with the pressure built up within the unit to avoid explosion. Mounting of the individual fuse may be internal or external to the capacitor case.

The Inputs to the APFC system is Voltage input from two phases and current input from the third phase. Out of two phases of voltage one phase voltage is taken as Reference 0 and another phase voltage as 440V. APFC need to be installed CT (Current Transformer) on the third phase at main incomer ACB after transformer, which shall give signal to the APFC Relay. Based on these inputs the ASIC (Application Specific Integrated Circuit) OR Call it as Microprocessor internal to the APFC Relay shall give output signal to relay outputs which shall energize coil of the contactor so that the contactor come in line connecting the capacitor bank in circuit. However, this is step correction means PF shall be corrected in steps. The Voltage rise due to connection of capacitor banks is marginal. There shall be no frequency correction with APFC System and APFC Relay shall have communication port (RS 485).

6.6.3 Power Capacitor and Control Panel

(a) Power capacitor and control panel shall be housed in metal enclosed cubicle. Power capacitor shall be housed in the lower compartment and capacitor control panel at top compartment.

(b) The control equipment including capacitors shall be mounted in a panel of cold rolled sheet steel. The panel shall be of indoor type and shall consist of:

- Busbars shall be of copper conductor of hard drawn (HD) and high conductivity. All bus shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.
- Isolating switch.
- Contactor with overload element.
- APFC Relays responsive to current/voltage/KVAR/PF as specified for automatic switching shall be of microprocessor based suitable for both for state board Electricity and DG set with reduced power factor.
- Sequencing devices, timers and auxiliary relays for automatic sequential switching of the capacitors in and out of the circuit.
- Auto-manual selector switches.
- Push button for opening and closing the power circuit.
- Red and green cluster LED lights for capacitors ON/OFF indication.
- Protective numerical relays to protect the healthy capacitor units when one unit fails in a series connection.
- Space heater and cubicle lighting as per the requirements.

6.6.4 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under “Bid/Contract Drawings”, Part 3, General Requirements, Volume-2 of Bid Documents.

6.7 Soft Starters

6.7.1 Applicable Standards

The design, manufacture and performance of equipment shall conform to the latest standards specified below.

Switchgear General Requirements	IS:13947/BS:5486/IEC:60947
Factory Built Assemblies of SWGR and Control gear for Voltages upto and including 1000V AC & 1200V DC	IS:8623/BS:5486/IEC:60439
Air Break Switches	IS:13947-P3 /BSEN60947 /IEC:60947-3
Moulded Case Circuit Breaker	IS 2516 / IEC 60947-2/ BS EN 60947-2
Miniature Circuit Breakers	IS:8828/BSEN:60898
Low voltage Fuses	IS:13703/BS:1362/IEC:60269-1
Contactors	IS:13947/BS EN60947-4 /IEC:60947-1
Starters	IS:13947/BS EN60947-4/IEC:60292-1 to 4
Control Switches / Push buttons	IS:6875 / BSEN 60947
Current Transformers	IS:2705/BS:7626

Voltage Transformers	IS:3156/BS:7625/IEC:60044, 60186
Indicating instruments	IS:1248/BS:89/IEC:60051
Marking and Identification of Conductors and Apparatus Terminals	IS:11353/BS:159
A.C. Electricity Meters	IS:722, 8530/BS:5685 / IEC 60145,60 211
Degree of Protection	IS:13947/IEC:60947-P1
Selection installation and maintenance of switchgear and control gear	IS:10118
Code of practice for phosphating coated iron and steel	IS:6005/BS:3189
Specification for copper rods and bars for electrical purposes	IS:613
Control transformers for switchgear and control gear voltage not exceeding 1000V AC	IS:12021
Classification of Hazardous areas having Flammable gases and vapours for Electrical Installation	IS:5572
Guide for Selection of Electrical Equipment for Hazardous areas	IS:5571
Electrical apparatus for explosive gas atmospheres-General Requirements	IEC:60079

6.7.2 Constructional and Performance Features

(a) The Soft start panel shall be indoor, metal clad, floor standing, compartmentalised complete with reactors, busbars, vacuum contactor, control, metering, protection equipment and indicating lamps, etc.
(b) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.
(c) The Soft starter shall achieve smooth starting by torque control for gradual acceleration of the drive system thus preventing jerks and extending the life of equipment.
(d) Protection shall be provided for Soft starters (semiconductor fuse).
(e) Starting current shall be limited to 3.0 times the full load current of the motor.
(f) The Soft starter shall have possibility for low speed forward and backward operation for positioning of a motor.
(g) The Soft starter shall have built-in diagnostics, fault detection and fault history.
(h) The Soft starter shall integrate motor and load protections, which shall under no circumstances be disabled when the integrated bypass shall be used. The following motor protections available along with warning function:
i) Electronic overload protection.
ii) Locked rotor protection.
iii) Motor under load protection.
iv) Current imbalance protection.
v) Voltage imbalance protection.
vi) Overvoltage & under voltage protection.

vii) Phase reversal protection.
viii) Total harmonic distortion (THD).
ix) Fans fault.
x) Thyristor overload.
xi) Number of starts.
xii) Motor run time limit.

(i) The Soft starter shall make it possible to run the motor in a weaker network and hence improving the availability of the system/equipment with followings types.

i) Current.
ii) Dual current limit.
iii) Current ramp.

(j) Separate removable gland plates shall be provided for power and control cables. The gland plate for the power cables shall be of non-magnetic material.

(k) All sheet steel work shall be thoroughly cleaned of rust, scale, oil, grease, dirt and swarf by pickling, emulsion cleaning etc. The sheet steel shall be phosphate coated and then painted with two coats of zinc rich primer plant. After application of the primer, two coats of finishing synthetic enamel paint oven baked/stoved, shall be applied.

(l) The cable alley shall house all power cable connections along with associated cable terminations.

(m) Each cubicle shall be fitted with a label in the front and rear of the cubicle, indicating the panel designation, rating and duty. Each relay, instrument, switch, fuse and other devices shall be provided with separate labels.

(n) Caution name plate with inscription "Caution - Live Terminals" shall be provided at all points where the terminals are likely to remain live and isolation shall be possible only at remote end, e.g. incoming terminals of main disconnecting switch.

(o) Starting of motor shall be from either Soft Starter panel located near to motor or shall be from MCC Panel or from PLC. Necessary wiring diagram shall be provided considering starting interlock, trip circuit, starting and running mode signal.

(p) The soft starter panel shall have soft start and soft stop facility during normal operation.
Thyristor fuses shall have a trip indicator to operate a suitable micro switch with least 1NO + 1 NC potential free contacts for annunciation and/or tripping.

(q) The soft starter panel shall be installed in Air Condition room, it shall not club with PCC/MCC panels.
The soft starter panel shall be provided with sufficient ventilation for each unit. Necessary exhaust fan, louvers with filters must be provided in the cubicle to ensure proper ventilation

6.7.3 Main Busbars

(a) Busbars shall be supported on insulators capable of withstanding dynamic stresses due to short circuit.

(b) Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. All busbars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

(c) The temperature rise of bus bars shall be limited to 40 degree centigrade over 45-degree centigrade ambient temperature.

(d) All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 "Code of Practice for Phosphate coated Iron and Steel". Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning. Rust and scale shall

be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphate coated, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying. The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be "flash dried" while the second coat shall be stoved. After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.

The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 120 microns.Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

6.7.4 Earthing

(a) An earthing bus shall be provided at the bottom and extended throughout the length of the panel. It shall be bolted/welded to the frame work.
(b) All non-current carrying metal work of the panel shall be effectively bonded to the earth bus. Hinged doors shall be earthed through flexible earthing braid.

6.7.5 Panel Accessories and Wiring

(a) Panel shall be supplied completely wired internally upto equipment and terminal blocks and ready for the external cable connections at the terminal blocks. Inter panel wiring between compartment of the same panel shall be provided.
(b) All auxiliary wiring shall be carried out with 1100volts grade, single core, stranded copper conductor with PVC insulation. The sizes of wire shall be not less than 1.5sq.mm.
(c) Terminal blocks shall be of stud type, 1100volts grade 10 amps rated, complete with insulated barriers. Terminal blocks for CTs shall be provided with test links and isolating facilities.
(d) All spare contacts and terminals of cubicle mounted equipment and devices shall be wired to terminal blocks.
(e) Accuracy class for indicating instruments (MFM with communication port-RS485) shall be 1.0. Instruments shall be 110/96 mm square, 240° scale for flush mounting with only flanges projecting.
(f) Relays shall be suitable for flush mounting with only flanges projecting.
(g) Push buttons shall be provided with inscription plates engraved with their functions.
(h) Indicating lamps shall be of LED type.
(i) Space heaters of adequate capacity shall be provided inside each panel. They shall be suitable for 240V, single phase, 50Hz supply. They shall be complete with MCBs, isolating switches and thermostat.
(j) Each panel shall be provided with 240 Volts, 1 phase, 50Hz, 5amps, 3pin receptacles with switch located in a convenient position. An interior illuminating CFL/LED lamp together with the operating door switch and protective fuses shall be provided.
(k) Provision shall be made for receiving, distribution, isolating and fusing of auxiliary supplies for controls, space heating etc. The fuse ratings shall be so chosen as to ensure selective clearance of sub-circuit faults.
(l) Fuses shall be HRC cartridge type mounted on plug in type fuse base.

(m) The auxiliary supply shall be distributed inside the panel with necessary isolating arrangements at the point of entry and with sub-circuit fuses as required.

6.7.6 Cable Termination

(a) Necessary number of cable glands shall be supplied for terminating auxiliary power and control cables. Glands shall be of heavy-duty brass castings, machine finished and complete with check nut, washers, neoprene compression ring etc.
(b) Cable lugs for all power and control cable connections shall be supplied. The lugs shall be tinned copper/aluminium depending on cable conductor and of solderless crimping type.
(c) All necessary materials required for terminating the power cables such as tapes, fillers, binding wires, armour clamps, brass glands etc. shall be supplied.

6.7.7 Drawings and Data

All Drawings, data, technical, particulars, temperature rise calculations, detailed literature, catalogues, test certificates etc., shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.8 Diesel Standby Generator

6.8. 1 Applicable Standards

The Diesel Standby Generator and its components shall conform to the latest applicable standards specified below:

Diesel Engines for General Purposes	:	BS 5514 / ISO 3046
The Electrical Performance of Rotating Electrical Machinery	:	BS 5000
Rotating Electrical Machines	:	IS 4722
Circuit breakers	:	IS-13118, BS-5311, IEC-56 & 694, BSEN-60942 (P-2)
Air break switches air break disconnectors, air break switch disconnectors and fuse combination units for voltage not exceeding 1000V AC or 1200V DC	:	IS-13947 (P-3), BS-EN60947, IEC-60947-3
Current transformer	:	IS-2705/BS-7626, IEC-60185
Voltage transformer	:	IS-3156/BS-7625/IEC 60186
Electrical Relays	:	IS-3231, 3842/BS-142/IEC-60255
Contactors for voltage not exceeding 1000V ac or 1200VDC	:	IS-13947 Part-IV/ BSEN-60947-4-1/ IEC-60947-4-1
Control Switches	:	IS-6875/BSEN-60947 / IEC-60947-4-1
High Voltage Fuse		IS-9385/BS-2692/ IEC-60282
Low Voltage Fuse	:	IS-13703/BS-1362 IEC-269-1

Electrical direct acting indicating Instruments	:	IS-1248/BS-89/IEC-60051
A.C. electricity meters of induction type voltage greater than1000 volts	:	IS722, 8530/BS-5685 / IEC-60145, 60211
Resistance wire, tapes and stripes for heating elements	:	IS-3725
Wrought aluminum and aluminum alloy bars, rods, tubes and sections for electrical purposes	:	IS-5082
Specification for copper rods and bars for electrical purposes	:	IS-613
Toggle switches	:	IS-3452/BS-3676
Control switches/push buttons	:	IS-6875/BSEN 60947
Nose and Emission Limit	:	As per latest notification of ministry of Environment and Forests

6.8. 2 General Requirements

The diesel engine and generator shall be skid mounted and shall be located in a room near treatment plant substation building. The diesel engine shall draw cooling air directly from outside the room through a weather proof, acoustically treated duct. The exhaust system shall be insulated to minimize the amount of heat entering the room and to prevent injury to personnel.

The exhaust system pipe shall be required height above the nearest building as per latest CPCB guideline. The exhaust pipe line diameter shall be suitably designed to avoid back pressure when discharged at higher elevation. The silencer shall be of the 'residential' type and be located externally.

The generation voltage shall be 415V for D.G capacity less than 2MVA and generation voltage shall be 11kV for D.G capacity more than 2MVA. If more than one D.G set shall be required for achieving the required load capacity they shall be operated in parallel with necessary synchronizing arrangement with LCD.

At no point D.G sets shall be operating parallel with grid. The tank shall be provided with fittings to permit the visual observation of fuel level and to enable filling by local tanker operators. A level sensor/switches shall also be mounted in the tank so that remaining fuel volume can be monitored at the generator / substation PLC and the operator stations in the SCADA room.

The fuel System shall comprise an engine driven feed pump with duplex filters, high level 990 litres day tank located in the generator room or generator skid mounted day fuel tank with supporting structure or generator skid mounted day fuel tank, with all inter connecting pipe work, flexible engine connection pipe etc. A semi-rotary hand pump shall be provided to permit transfer of fuel in the event of a failure of the transfer pump. Any leakage from the pumps shall be routed to the bund.

A fire alarm system shall be provided within the generator room to detect fire, to raise a local audible alarm (manually silenced locally).

All alarms shall be conveyed to the central SCADA through the PLC.

6.8. 3 Diesel Generating Set Automatic Control

AMF Diesel Generator Set capable of automatic starting and picking the load within 30seconds shall be provided to cater for emergency loads and lighting during mains power failure. Diesel generating set for use in auto mains failure mode shall have a three position automatic / off / manual selection and shall operate as follows:

(i) Automatic mode:

On occurrence of mains failure, the following sequence shall be followed.

(a) Mains to Generator changeover.

- mains failure detected.
- delay of 10 seconds.
- generator shall be started and run up to speed.
- time delay of 50 seconds.
- mains supply shall be switched off.
- generator supply shall be switched on.

(b) Generator to Mains changeover.

- mains restored and healthy detected.
- manual changeover signal received.
- generator supply shall be switched off.
- mains supply shall be switched on.
- generator runs for 2 minutes and stops.

All timer settings shall be adjustable.

If mains power shall be restored during the initial one-minute delay then the power shall be monitored for a further one minute and if it shall be still healthy, mains power shall be restored. The generator shall be stopped after a further 2 minutes of running on no load. If the generator fails to start after an initial period of cranking, two further attempts shall be made with an appropriate interval between each attempt. If the engine fails to start after three attempts the system shall shut down and a local and remote alarm shall be annunciated.

(ii) Manual mode:

The generator shall run to the dictates of manual controls on the generator. No automatic changeover of mains to generator supply or vice versa shall take place. The generator shall be loaded by manual switching if required.

6.8. 4 Alternator for Diesel Generating Set

The generation voltage shall be 415V for capacity less than 2MVA and generation voltage shall be 11kV for capacity 2MVA and above.

Alternator shall be 4 pole, 3 phase,50 Hz, 0.8 P. F, salient pole, revolving field, Brush less type, self-regulating continuously rated and manufactured in accordance with IS 4722, BS 5000: Part 99 or IEC 60034-1. They shall be totally enclosed, screen protected, fan ventilated and vertical drip-proof conforming to IP 23.

The Alternator shall be complete with excitation system, AVR and all necessary auxiliaries. The alternator shall be driven by diesel engine detailed below and shall match the same in all respects. The terminal box shall be dustproof with IP 54 degree of protection. The terminal box shall be suitably sized to terminate the size and number of cables involved. Alternators shall be capable of

withstanding a 10% overload for 1 hour in any 12 hours Period under the specified conditions of temperature, humidity and atmospheric pressure.

Alternator windings shall be of Class H insulation with Class F temperature rise and tropicalised. The alternator shall have pre-packed grease lubricated ball or roller bearings and provided with facilities for degreasing whilst in service. The alternator shall be foot mounted on a common bedframe with the prime mover close coupled to the engine flywheel housing. The direction of alternator rotation when viewed from the driven end shall be clockwise and phase voltage sequence UVW. The alternator vibration level shall not exceed the values defined in IS 12075.The alternator shall be capable of maintaining a short circuit current of three times full load current for a period of 10 seconds.

The alternator shall be fitted with an anti-condensation Alternator shall have 6 nos. duplex RTDs inside the stator winding. No individual harmonic shall exceed 1% and the total harmonic shall not exceed 3%. The alternator, it's neutral and control panel shall be earthed as per relevant standards. Alternator rotor assembly shall comprise exciter rotor, full wave silicon bridge rectifier, surge protection device and salient pole rotating field system.

The rotor shall be fitted with interconnected pole face damping windings. Voltage regulation shall be maintained to within ±2.5% for a power factor of 0.8 to unity, including hot to cold variations. The steady state frequency droop between no load and full load shall not exceed 5%. Transient voltage deviation following a step load of 60% of rated at a power factor of between 0.4 and zero shall not exceed 15% with a voltage recovery time to 97% rated voltage not exceeding 0.5second.

The set shall be capable of continuous operation with a phase current imbalance of 33% of rated current whilst maintaining the output voltage within ±5% of rated. Alternator shall have sensors for alternator protection and shall be wired to control panel. The alternator shall be provided with class F insulation with temperature rise limited to that of class B insulation.

6.8. 5 Diesel Engine for Generating Set

Engine shall be four-stroke, direct injection, and turbocharged industrial machines. They shall be fitted with renewable wet cylinder liners if water cooled and shall be direct coupled to the alternator and mounted on a common rigid steel bedplate. Engines shall be rated for continuous duty at site ambient conditions with an inherent O/L Capacity of 10% for 1 hour in any 12 hours. The engine shall be capable of running at full load for not less than 180 hours without maintenance adjustments and 10,000 hours between major overhauls. The maximum operating speed shall be 1500 rpm. The range of manual adjustment shall not be less than ±5% of rated speed. The performance of engine governors under load conditions shall be to Class A2 in accordance with BS 5514: Part 4.

Engine governors shall be suitable for remote control load sharing between identical engine units. In addition to any electrical over speed trips, there shall be a mechanical over speed device which shall operate at 120% of the rated speed. Re-setting of the over speed trip shall be possible by hand only. The steady state output speed drop between no load and full load shall not exceed 5%. The transient output speed deviation shall not exceed 10% for a step of 60%.

Engines shall be designed to run on fuel oil complying with IS 1460 or BS 2869, Class A2.Engines shall be cooled by means of a water jacket, heavy duty air blast radiator with integral radiator header tank, circulating pump and engine driven pusher type fan. The fan shall draw air in from the vicinity of the engine block and discharge it through the radiator core. The radiator shall be mounted on the same bedplate as the engine and alternator on suitable vibration isolators and be arranged so that it shall be located directly behind automatic louvers set into the external wall of the engine room. A

thermostatically operated by-pass valve shall be fitted in the cooling system to maintain an optimum operating temperature during starting and running conditions. Drain cocks shall be provided so that all the water can be drained from the system. A separate oil cooler shall be used for cooling the engine oil. A thermostatic by-pass valve shall be incorporated.

Engine lubrication shall be by a closed-circuit wet sump, forced feed system supplied by an engine driven pump fitted with pressure regulating and relief valves, sump suction filter and changeover renewable micro-felt full flow line filters. A hand operated semi-rotary oil pump shall be installed to carry out initial priming or to fill or empty the sump as required. The sump shall be fitted with an easily accessible drain point. The oil shall be of the grade recommended by the engine manufacturer.

The starting system shall comprise 12 or 24V heavy duty lead acid batteries (positioned on a floor mounted stand adjacent to the engine) connected by heavy duty flexible butyl rubber cables. Batteries shall be sized to give six consecutive starts of the engine at 0°C. An engine driven alternator and charging system shall be provided. An automatic main energized battery charger shall be provided, with sufficient capacity to maintain the battery in a condition to full fill the starting requirements.

Barring (hand turning) equipment shall be provided so that the engine can be manually rotated for maintenance purposes. It shall be arranged so that normal starting of the engine shall be inhibited whilst the hand turning equipment shall be connected.

Twin heavy-duty air intake filters in accordance with IS 3169 or BS 7226 suitable for operating in dust laden atmospheres shall be fitted. The filters shall be of the paper element with pre-cleaner type. Turbo charger filters shall be fitted. Breathers shall be fitted with washable filters which are easily accessible for maintenance.

Instrumentation shall be provided to monitor speed, oil pressure, oil temperature (sets larger than 250kVA), water temperature and battery charge current. The bedplate shall be of heavy gauge steel construction, stress relieved and free from distortion. Engine shall be provided with sensors for engine protection and shall be wired to control panel.

Machined surfaces shall be incorporated for mountings and for levelling. Anti-vibration mountings shall be fitted between the bedplate and the floor to prevent vibrations being transmitted to the building. The mountings shall be adjustable for levelling purpose and shall be designed to resist horizontal movement of the diesel set.

The fuel system shall comprise an engine driven feed pump with duplex filters, 990 litres day tank with supporting structures or generator skid mounted day fuel tank with all inter connecting pipe work, flexible engine connection pipe etc.

6.8. 6 Diesel Generator Control Panel:

The control panel shall have provision such that inter-operability with instrumentation control system. The control panel with communication facility shall be separately mounted on anti-vibration mountings and shall comprise the following:

- Breaker incorporating short circuit and overload trip.
- Earth fault protection for the Alternator.
- Alternator Over & Under Voltage Protection.
- Voltage Controlled Over Current Relay.
- Voltmeter with built in selector switch /(digital)
- ammeter with built in selector switch / (digital)

- frequency meter
- Power Factor Meter
- KWh Meter (Multifunction meter)
- Engine temperature and oil pressure gauge
- service hours run indicator
- key switch starts and stop control
- operational status indicator
- anti-condensation heater and thermostat
- alternator anti-condensation heater controls
- mains fed battery charger
- Auto start on mains power supply failure facility
- Fails to Start (Alarm)
- Over / Under Voltage (Alarm)
- Battery Charger Fault (Alarm)
- Low fuel Oil Level (Alarm)
- Over Load (Alarm)
- Low Lube Oil Pressure (Trip)
- High Water Temperature(Trip)
- High Lube Oil Temperature (Trip)
- Electrical Protection Relays (Trip).

A reset button shall be provided to cancel the alarm /shut-down condition prior to re-starting.

Simple operating instructions shall be detailed on the fascia of the control panel. All alarm and trip status signals from diesel supply system, engine control panel and alternator protection shall be hard wired to a marshalling box for instrumentation control system.

Busbars shall be of copper conductor of hand drawn (HD) and high conductivity. All bus bars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

6.8. 7 Synchronising Panel

Whenever two or more sets are required to operate together, necessary synchronizing panel complete with circuit breaker, synchro scope, numeric relays, digital meters etc shall be provided. The Panel shall be floor standing, CRCA Sheet steel enclosed.

6.8. 8 Acoustic Enclosure

(i) The DG Set shall be provided with acoustic enclosure, fully integrated, weather proof with superior finish for long and durable life.
(ii) The acoustic enclosure shall be CRCA sheet steel enclosed with necessary panels and doors, inside lining of fire-retardant foam/glass wool as acoustic material.
(iii) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.
(iv) The sound level shall be restricted to 75dB at a distance of 1 meter, under full load, free field conditions as per relevant standards.
(v) The acoustic enclosure shall be certified to meet the emission norms.

6.8. 9 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.9 UPS, Battery, Battery Charger and D.C Distribution Board

UPS shall be supplied as per Instrumentation specification. UPS, Battery, Battery Charger shall be three phase incoming supply with breaker. DC equipment shall comply with IEC 60896 including those standards referred to therein.

6.9.1 General Requirements

Following items shall be covered in the Contract:

- One no. 110V Nickel Cadmium type Battery Bank (Minimum capacity of Battery 100Ah).
- One no. Float-cum-boost charger for 110V batteries.
- DC distribution board.

All connections between battery, battery chargers and DC distribution board shall be designed for effective segregation between positive and negative leads.

6.9.2 Nickel - Cadmium Battery

Design Features

(a) Battery offered shall be Nickel Cadmium (Ni-Cd), Sintered Type. The battery shall conform to the latest applicable standards specified below:

Specification for sintered type : IS 10918
Nickel Cadmium Sintered Batteries

(b) Nickel hydroxide and Cadmium hydroxide shall be used for positive and negative electrode respectively. Aqueous solution of battery grade Potassium hydroxide with small quantities of lithium hydroxide shall be used as electrolyte. It shall be used only for ion transfer and shall not chemically change during charging/ discharging.

(c) The containers shall be transparent and preferably be made of toughened glass or plastic polypropylene material and provided with electrolyte level indicator. The Containers shall be robust, heat resistant, leak proof, non-absorbent and free from crack, blisters, pin hole etc.

(d) The battery shall be rated on 5-hour basis and for the specified ambient temperature. The battery shall have maximum recharge time of 8 hours.

(e) Terminal posts shall be designed to accommodate external bolted connection conveniently and positively. Each terminal post shall have two bolt holes of the same diameter, preferably at right angles to each other. The bottom hole shall be used to terminate the inter-cell connection. The top hole shall be left for external terminal connections. Bolts, heads and nuts, except seal nuts, shall be hexagonal and shall be lead covered. The junction between terminal posts and cover and between cover and container shall be so sealed as to prevent any seepage of electrolyte.

(f) Required quantity of electrolyte for first filling with 10% extra shall be supplied in non-returnable containers.

(g) Each battery shall be complete with following accessories, as applicable, that include, but are not limited to:

(i) Battery racks.

(ii) Porcelain insulators, rubber pads, etc.

(iii) Set of inter-cell, inter-tier and inter-bank nickel coated copper connectors as required for the complete installation.

(iv) Electrolyte for first filling + 10% extra.

1 set of accessories for testing and maintenance shall also be provided suitable for all the three battery banks.

i.	One	-	-3, 0, +3 volts DC voltmeter with built-in discharging resistor and suitable leads for measuring cell voltage.
ii.	One	-	Filler hole float fitted with plug and cap and having specific gravity correction scale.
iii.	Three	-	Digital portable Pocket thermometers.
iv	Two	-	Cell lifting straps.
v	One set Each of	-	Terminals and cable boxes with glands for connecting cable as required. Spare connectors. Spare vent plugs. Spare nuts and bolts. Suitable set of spanners.

(h) Each battery shall be mounted in a manner that permits easy accessibility to any cell. The racks shall be suitable for fixing on flat concrete floor. The complete racks shall be suitable for bolting end to end.

(i) It shall be the responsibility of the contractor to provide batteries of adequate capacities to meet specified requirements pertaining to control, indication, annunciation, etc. and emergency lighting. For computing battery capacity, it shall be assumed that the battery is fully charged at the beginning of loading cycle and is discharged to a voltage of 1.2 volts per cell at the end of the loading cycle. The battery shall have minimal difference (approx. 0.3 V per cell) between float and boost charging voltages.

(j) The following information shall be legibly marked on outside each cell.
Manufacturer's Name & Trade Mark.
Country & Year of Manufacture.
AH Capacity at 5-hour discharge rate.
Type Designation &Sl. No.

6.9.3 Drawing

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.9.4 Battery Charger and D.C. Distribution Board

Applicable Standards

The battery charger and D.C. distribution board shall conform to the latest applicable standards specified below. In case of conflict between the standards and this Specification, this Specification shall govern.

Basic climatic and mechanical durability tests for components for electronic and electrical equipment	:	IS:9000
Environmental tests for electronic and Electrical equipment	:	IS:9000
Metal clad base material for printed circuits for use in electronic and telecommunication equipment	:	IS:5921
Transformers and inductors (power, audio, pulse and switching) for electronic equipment	:	IS:6297
Printed wiring boards	:	IS:7405
Environmental requirements for semi-Conductor devices and integrated circuits	:	IS 6553
Terminals for electronic equipment	:	IS:4007
Factory built assemblies of switchgear and control gear for voltages up to and including 1000V AC and 1200V DC	:	IS:8623/ BS: 5486/ IEC:60439
Air break switches	:	IS: 13947 (Part - 3) BSEN60947-3
Miniature circuit breakers	:	IS 8828/BSEN:60898
HRC cartridge fuses	:	IS:9224/BS:88
Contactors	:	IS:13947 (Part - 3) /BS:775
Control switches/push buttons	:	IS:6875
Indicating instruments	:	IS:1248/BC:89/ EC:51
Degree of Protection	:	IS:13947- (Part 1) / IEC:60947-1
Climate-proofing of electrical equipment	:	BSCP:1014
Code of practice for phosphate coated iron and Steel	:	IS:6005/BS:3189
Semi-conductor converters	:	IEC:60146
Semi-conductor rectifier equipment safety code	:	IS:6619
Specification for copper rods and bars for electrical purpose	:	IS: 613

6.9.5 Battery charger

(a) Battery charger shall be combined float-cum-boost (FCB) type. FCB unit shall be considered 2nos for each Battery charger to maintain redundancy.

(b) The charger shall be static type composed of silicon-controlled rectifiers (SCRs) and diodes connected in three phase full wave half controlled bridge circuit.

(c) The rectifier transformers for float and boost chargers shall be indoor dry type, double wound with delta-star connections. The BIDDER shall ascertain if taps are required and provide adequate number of primary and secondary taps, if necessary.

(d) The float charger shall be designed for supplying:

(i) The D.C continuous load and short-time overload.

(ii) The trickle charging current of the battery.

(e) The boost charger shall be designed for supplying the boost charging current of the battery.

(f) If the battery and charger are to be supplied by separate contractors, the charger contractor shall coordinate with the battery contractor regarding float /trickle boost charging current & voltages required for the battery.

(g) Battery Charger shall be provided with facility for both automatic and manual control of output voltage and current and necessary selector switch shall be provided. contractor regarding the float/trickle and boost charging current and voltages required by the battery.

(h) Performance

(i) Float Charger

The D.C. output voltage during float charging shall be stabilized within ±1% of the set DC bus voltage. Manual control shall be used if auto mode fails.

(ii) Boost Charger

For boost charging the discharged battery after a mains failure, the rectifier shall charge the battery at high rate limited to the maximum boost charging voltage. After a specified number of hours (adjustable) when the rated cell voltage shall be reached, the charger shall be returned to float charge status.

- In case of combined float cum boost charger, the switching and control of high rate charge and return to float charge shall be by automatic controller/regulator. Manual control shall be used if auto-mode fails.
- During boost charging following emergency measures shall be provided:
- If the AC mains supply fails, an arrangement shall be made to automatically connect the battery directly across the load.
- If the separate or spare float charger supplying D.C. load fails, the load shall be fed from the point of connection at the tapping of the battery via adequately rated blocking diodes.

(iii) Suitable filter Circuits shall be provided in the chargers to limit the ripple content (peak to peak) in the output voltage to 1% irrespective of D.C Loads.

(i) The D.C System shall be unearthed. sensitive earth fault detectors shall be provided in D.C system to annunciate earth fault.

(j) Special digital ammeter with zero centre for status of battery charging and discharging.

(k) All other meters shall be digital type only.

6.9.6 Charger Panel and D.C. Distribution Board

(a) Battery charger panel and D.C. distribution board shall be sheet metal enclosure free standing type with cable entry from bottom.

(b) Indications, controls and output voltage setting adjustments shall be on front panel. The contractor shall submit a scheme for alarm and trip indication lamps on the cabinet and for fault annunciation contacts paralleled for remote annunciation.

(c) The components shall be liberally rated and housed in a well-ventilated sheet metal cubicle complete with input and output terminals. Louvers shall be provided for ventilation backed up by fine wire mesh so that the degree of protection shall be equal to or better than IP-42.

(e) Busbars shall be of Electrolytic copper Grade conductor of hard drawn (HD) and high conductivity. All busbars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

(d) All printed circuit cards shall be plug-in type, interlocked to prevent insertion in a wrong slot. Each card shall have LED indication on its front plate to indicate normal condition and readily and marked test pins.

(e) Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

(f) All components shall be accessible to the maintenance technician for easy disassembly and replacement. Access to parts of equipment shall be with minimum danger from all hazards.

(g) All components and modules shall be clearly and unambiguously marked and all wiring colour-coded and tagged.

(h) All power and control wiring within the cubicle shall be done with stranded copper wires. The power wiring shall be adequately sized for the required rating. The minimum sizes for control wiring shall be 1.5 sq.mm and for power wiring shall be 2.5 sq.mm 650 / 110V grade.
(i) Ground terminals with isolating links shall be provided.
(j) Cable glands shall be provided to suit the incoming and outgoing cables.
(k) DC DB shall meet the emergency lighting requirement also.

6.9.7 Components/Accessories

(i) The main items are listed below. However, additional items required for completeness or to meet the specified performance or operational requirements of the charger, shall be deemed to be included in the contractor's scope. Instead of incoming ON/OFF switches, sticker fuses and contactors, the contractor may provide suitably rated 3 pole MCBs with overload and short circuit protection and auxiliary contacts.
(ii) One (1) set - Three phase full wave half controlled bridge rectifier circuit comprising silicon controlled rectifiers and silicon diodes complete with resistor/capacitor network for surge protection. The diodes/SCRs shall be individually protected by fuses with fuse fail indication.
(iii) One (1) Double wound, dry type, three phases suitably rated mains transformer.
(iv) One (1) set of suitably rated control transformers for electronic controller.
(v) One (1) Electronic controller comprising of power supply card, soft start cum current limit card, auto trickle mode card with facility for setting trickle charge current and monitoring battery current, error amplifier cards and pulse generating cards for achieving the DC output voltage stabilisation of ±1% and also for achieving current limiting feature. The electronic controller shall have protection features with indications for under-voltage, over-voltage, set output voltage and phase failure or voltage unbalance.

The electronic controller shall be provided with following features.

- Boost current stabilization of ±2% with AC input variation of voltage and frequency variation of ±10% and ±5% respectively.
- Boost charge current limiter with potentiometer to adjust the setting.

(vi) Adequately sized necessary built-in accessories shall be provided such that on failure of the controller in auto mode the voltage can be effectively controlled manually.
(vii) One (1) Filter circuit comprising of smoothing choke and condensers complete with HRC fuse with trip indication for filter condenser circuit.
(viii) One (1) Auto/Off/Manual selector switch for selecting the mode of operation of the controller.
(ix) One (1) front panel mounted potentiometer for set point adjustment of output voltage in auto mode.
(x) One (1) front panel mounted potentiometer for manual adjustment of voltage in manual mode.
(xi) One (1) TP AC ON/OFF switch for float charger incoming.
(xii) One (1) set of MCB / HRC fuses complete with fittings for AC input with suitable ratings and trip indication.
(xiii) One (1) set of the pilot lamps with series resistors to indicate float charger AC Mains 'ON' condition.
(xiv) One (1) Digital voltmeter, ammeter and frequency meter for Mains.
(xv) One (1) AC contactor with suitably rated coil and three main and 2 NO + 2 NC auxiliary contacts, suitably rated thermal overload relay and ON/OFF control switch.
(xvi) One (1) set of HRC fuses complete with fuse fittings for the DC output, and with trip indication.
(xvii) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the float charger output current.

(xviii) One (1) moving coil DC ammeter, with shunt, of size 96 x 96 mm and suitable range to read the charging and discharging current for battery.
(xix) One (1) Double pole DC ON/OFF MCB switch for float charger output.
(xx) One (1) pilot lamp with series resistor to indicate float charger DC 'ON' condition.
(xxi) Annunciation System with communication facility for the following

- AC Supply Failure.
- Rectifier Fuse Failure.
- Surge Circuit Fuse Failure.
- Filter Fuse Failure.
- Load Limiter Operated.
- Charger Trip.
- Battery on Float.
- Battery on Boost.

6.9.8 Power Electronic Components

(a) Diode and thyristors shall be of mono crystal line type silicon, capable of continuous output at specified voltages. It shall have high power efficiency.
(b) If many diode or thyristor assemblies are connected in parallel, care shall be taken to ensure that each rectifier or thyristor operates within its rating and shares the load uniformly. This may be achieved with the help of chokes. Also, care should be taken to select matched pairs of rectifier heat sink units.
(c) Each diode or thyristor built in a multi-built assembly shall be provided with a short circuit protection to avoid complete shut-down of the equipment because of a fault on single unit. Suitable fuses shall be provided for such protection.
(d) Necessary spare capacity shall be built in the equipment to continuously supply full load even with one unit out of circuit.
(e) The diodes or thyristor banks shall be natural air cooled.
(f) The diodes or thyristors shall be protected against over voltage due to chopping surges with the aid of snubbers (i.e. resistor-capacitor combination and Metal oxide varister). It shall be ensured that normal load currents and especially fault currents are shared equally between parallel links, within the specified limits. To achieve this, great care shall be taken to design the layout of the rectifier links to ensure equal lengths of busbars and as near as possible identical contact resistance in each current path.

6.9.9 Drawings and Data

All Drawings, data, technical particulars, temperature rise calculations, detailed literature, catalogues, type test certificates of typical transformer etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.10 Variable Frequency Drives

Variable Frequency system shall have provision such that inter-operability with instrumentation control system for flow control.

6.10.1 Applicable Standards

a)	Specification for metal clad base materials for printed circuits for use in electronic and telecommunication equipment	:	IS:5921
b)	Specification of Transformers and Inductors (Power, Audio, Pulse and Switching) for Electronic Equipment	:	IS:6297
c)	Semiconductor rectifier equipment safety code for	:	IS:6619
d)	Specification for printed wiring Board	:	IS:7405
e)	Recommended practice for emergency and stand by power systems for industrial and commercial application	:	IEEE:446
f)	Semiconductor devices	:	IS:3700
g)	Basic climate for mechanical durability tests for electronic components	:	IS:9000
h)	Environmental requirements of semiconductor devices and integrated circuits	:	IS:6553
i)	Ambient temp. of electronic Equipment	:	IS:9676
j)	Terminal for electronic equipment	:	IS:4007

6.10.2 Configuration

Frequency drives shall have one of the two configurations given below Suitable for induction motor protection of all types confirming to IS325/IS13947 (Part4/set 1)1993 / IEC 947-4-1 (1990):

(a) Current source inverter.
(b) Voltage source inverter.

6.10.3 Converter

The Converter shall be of full wave rectifier type with minimum number of pulses 6 or more Smoothing Reactors for Current and Voltage Source Inverter.

(a) The smoothing reactor shall be sized to avoid conditions of discontinuous current
(b) Drives shall have ultra-low harmonic drive (ULH) to reduce harmonic reduction to less than 5%THDi (total harmonic distortion-current and voltage). Modern, compact, all-in-one solution that ensures harmonics are mitigated at source at all loads when connected to either a mains or generator supply.
(c) Operation of the frequency converter at its lowest frequency of operation, which shall not be less than 5Hz.
(d) The smoothing reactor shall be uniformly insulated and shall be protected for voltage surges occurring during sudden load throw-off.
(e) The smoothing reactor shall be made from electrolytic grade copper and shall be epoxy encapsulated with suitable class of resin decided from techno-economic considerations and performance requirements in conformity with IEC-146.
(f) Drives shall have cooling fans for additional energy saving during partial load situations.
(g) Semiconductor fuse shall be provided for protection of drive.
(h) Drives shall have built-in EMC filters suitable for network connection as standard.
(i) Drives shall have following features:

(i) Level control.
(ii) Pump cleaning.
(iii) Intelligent multi-pump control.

(iv) Flow calculation.
(v) Pump protection.
(vi) Quick ramps.
(vii) Turbidity reduction.
(viii) Communications loss backup mode.
(ix) EMC compliance.
(x) Modbus protocol.
(xi) Safe torque off.

6.10.4 Inverter

The inverter system suitable for three phase output shall consist of the following subsystems:
The basic inverter circuit consisting of the switching device say Thyristors/ Transistors/IGBT/MOSFET, connected so as to supply three phase power.

(a) The logic network to enable rapid transition of the main inverter switching devices from on-state to off-state.
(b) Suitable feedback system to allow balance of reactive power flow during load power factor fluctuation as well as regeneration.
(c) The filter system of the inverter output to suppress 5^{th}, 7^{th}, 11^{th}, 13^{th} harmonics at the output of the inverter to less than 5% of the fundamental amplitude.
(d) The ripple control system to limit current ripple to 4% at the input terminals of the inverter caused by distorted current output.

The output frequency of inverter shall be controlled to within the limits.

6.10.5 Inverter for AC drive

(i) Current Source Inverter

(a) Constant Torque Operation
The current output by the DC link shall be accurately monitored so that the ratio of the terminal voltage of the motor and the corresponding frequency remains constant. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.
(b) Constant Horsepower Operation
In this type of operation, the motor's internal voltage shall be maintained within + 1% while the frequency of the inverter shall be varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, alarm/annunciation and fault diagnostics shall be provided.

(ii) Voltage source Inverter

(a) Constant Torque Operation
The DC voltage input to the inverter shall be accurately monitored to maintain the ratio the terminal voltage of the motor to frequency at the rated/design value. The DC voltage input shall be maintained within + 1% of the required value. Should this fall for any reason, necessary action for tripping the frequency converter and initiation of annunciation/alarm and fault diagnostic shall be provided.
(b) Constant Horsepower Operation
In this type of operation, the voltage at the terminals of the motor shall be maintained within +1% of the rated value while the frequency of the inverter shall be varied to meet the duty cycle requirements. Necessary protective features for tripping the frequency converter, initiation of alarm/annunciation and fault diagnostic shall be provided.

6.10.6 Output Overcurrent Limit

Unless otherwise stated, the inverter shall be capable of being temporarily overloaded to 150% of its full load ampere capacity for sixty (60) seconds beyond which a current limit action shall be initiated, and an alarm contact initiated for annunciation.

6.10.7 Control Modules

All elements of the control system shall be mounted on epoxy laminate boards and each board shall be a plug in module mounted on a standard nineteen inch rack which shall be accessible from the front. Each card shall have LED indication on its front plate to indicate normal condition of the card. Readily accessible and clearly marked test pins shall be provided at the important points on the cards to enable signal analysis.

The epoxy laminates shall be free from manufacturing errors and shall be designed to prevent incorrect insertion in the card rack. The copper side of the card shall be suitably lacquered to prevent oxidation. The gap between two cards shall be sufficient to permit adequate ventilation.

Adjustments susceptible to change by accidental contact shall be lockable.

6.10.8 Control Requirements

Short time voltage dips upto 80% of nominal (e.g. in case of large motor start-up connected to same bus) shall not cause the control system to stop functioning and shall not trip the drive system.

The drive motor shall be speed regulated corresponding to 4-20mA or 0-10V reference input signal. Upon complete loss of users speed reference signal, the drive shall automatically run at constant speed as determined by the last speed reference available prior to loss of the signal.

The required provision for interfacing with PLC/DCS, including details of communication module and data transfer facility, I/O details shall be furnished by the Bidder.

6.10.9 Protection

Protection of Power Semiconductor
Each power semiconductor shall be protected against short circuit. The fuse shall be sized so that its I^2t does not exceed the I^2t characteristic of the power semiconductor itself. The voltage and current rating of the fuse shall match the duty on the power semiconductor. The arc voltage, due to melting of the fuse shall not exceed the repetitive peak reverse voltage of the power semiconductor.

Thyristor fuses shall have a trip indicator to operate a suitable micro switch with at least 1 NO + 1 NC potential free contacts for annunciation and/or tripping.

A fast tripping feeder circuit breaker shall be used in case fuses for short circuit protection of thyristors are not used.

Protective Systems for AC Inverter Drive
Fuses for all power semiconductors and/or other devices like commutation chokes, capacitors etc. which are not adequately protected against flow of abnormal currents.

Under voltage and over voltage protection on the input side. Loss of input voltage to inverter shall entail tripping of the inverter.

Protection for all control cards, power supply stabilizers, filter circuits etc. Protection shall be provided such that failure of a part does not cause damage elsewhere in the system.

- Polarizing relay to prevent reversal of polarity on the input side of the inverter.
- Protection of inverter thyristor, commutating circuits and other inverter elements during regenerative operation of the inverter and also during sudden load throw-off.
- Current limit fuses at the output of the inverter.
- Commutation circuit under voltage.
- Inverter over frequency.
- Programmable over current.
- Phase sequence/loss of phase protection.
- Earth fault protection.
- DC link overvoltage protection.
- Specific motor protection.
- Incoming line surge protection.
- Ventilation Loss.
- Over temperature.

6.10.10 Cooling of Power Converters

Power semiconductors shall be mounted on heat sink which can be individual or common to a number of devices. Adequate provision for clamping and mounting the power semiconductors shall be available.

Cooling of power semiconductors can either be natural air cooled or forced air cooled. The BIDDER shall recommend the type of cooling. However, for power converters which exceed capacities of 2 kA continuous load, alternative cooling methods as oil or water cooling shall be considered. The power semiconductors shall preferably be double side cooled.

6.10.11 Switching Devices

Switching devices such as circuit breakers, isolators, contactors; switch-fuse units etc shall be considered in the scope of supply.

The switching devices shall be enclosed in a separate enclosure forming the set of panels for the power converters. They shall have adequate clearance both with adjacent devices and metalwork at earth potential. Connection between devices shall be by adequate size of electrolytic grade of copper strips. These connections shall be adequately braced and insulated.

6.10.12 Constructional Features

The controller should have modular construction to facilitate maintenance.

The drive rating 22kW and above there is a separate (VFD panel) panel shall be provided and installed in Air Condition room, it shall not club with PCC/MCC panels. For protection semiconductor fuse shall be provided for Variable Frequency Drives (VFD).

Busbars

Power connections shall be of the bolted type and mating surfaces shall be tinned. The bus bars running to various converters shall be suitably designed to ensure equal sharing between the parallel strings and prevent mechanical stress on the fuse.

All bus bars shall be of Electrolytic copper Grade conductor of hard drawn (HD) and high conductivity All bus bars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

All cubicles shall have copper earth buses of adequate size running the entire cubicle height along the sides.

Cubicle

Cubicles housing the power semiconductors and drive level control system shall conform to IP 42 degree of protection to enclosures.

Panels shall be free standing, floor mounting type and shall comprise rigid welded structural frames enclosed completely with cold rolled sheet steel of thickness no less than 2.5 mm for front and rear portions and 2.0 mm for sides, top and bottom portions. There shall be sufficient reinforcement to provide level surfaces, resistance to vibrations and rigidity during transportation and installation. Stiffeners shall be provided wherever necessary to strengthen the door and side covers.

All doors, removable covers and panels shall be gasketed all round with neoprene gaskets, exhaust fans, ventilating louvers shall have screens and filters to heat dissipation. The screens shall be made of either brass or GI wire mesh.

Design, material selection and workmanship shall be such as to result in a neat appearance inside and outside with no welds, rivets or belt heads apparent from outside, with all exterior surfaces true and smooth.

Painting

All sheet steel work shall be phosphate coated in accordance with the following procedure and in accordance with IS: 6005 “Code of Practice for Phosphate coated Iron and Steel” Oil, grease, dirt and swarf shall be thoroughly removed by emulsion cleaning Rust and scale shall be removed by pickling with dilute acid followed by washing with running water, rinsing with slightly alkaline hot water and drying.

After phosphate coated, thorough rinsing shall be clean water followed by final rinsing with dilute dichromate solution and even drying.

The phosphate coating shall be followed by the application of two coats of ready mixed stoving type zinc chromate primer. The first coat may be “flash dried” while the second coat shall be stoved.

After application of the two coats of primer finishing synthetic enamel paint shall be applied, each coat followed by stoving. The second finishing coat shall be applied after completion of tests.

The final finished thickness of paint film on steel shall not be less than 80 microns and shall not be more than 100 microns.

Finished painted surface of panels shall present an aesthetically pleasing appearance free from dents and uneven surface.

A small quantity of finishing paint shall be supplied for minor touching up required at site after the installation of the panels.

6.10.13 Bins and Printed Circuit Cards

Individual bins shall be mounted on a swing able frame so that the connections at the rear are also accessible.

Self-retaining thumb head screws shall be needed for holding the bins in position. Adequate number of card/bin extenders for testing of PCBs shall be provided, each with flexible cables at least two meters long. These extenders shall be of a universal type suitable for use with any card / bin as the case may be.

All adjustments which are to be made while changing a card shall be outside in a separate module preferably plugged into the regulator bin.

Locking of individual cards in a bin shall preferably be through self-retaining thumb-head screws. Control modules shall be in the form of plug in packages, plugged into a module bin. Each plug in unit shall consist of a strong frame on which a printed circuit board would be permanently screwed. The plug connections shall only be of the pin type.

The printed circuit board (PCB) shall be made of glass fibre filled with epoxy laminates. The plug in unit shall be screwed to the basic socket in the module bin with long through bolts and knurled heads.

The front plates of the plug-in unit shall have the switches, the potentiometers, miniature monitoring meters, test points etc. Each plug-in unit shall have its own identification legend.

All plug-in units shall be polarized to prevent incorrect insertions into the module bin.

The gap between two plugs in units inside a bin shall be sufficient to permit adequate ventilation.

The copper side of the printed circuit board shall be lacquered to prevent oxidation. Each side of the printed circuit board shall have a shield cover to prevent inter circuit and external interference.

The PCB shall be mounted on PCB guides fixed on standard racks and the shield properly grounded. Control circuit test points shall be easily accessible for monitoring and maintenance.

6.10.14 Annunciation

The annunciate shall work on DC power supply with communication facility (RS 485 port) Fault and Trip shall be separately communicable with PLC. Each annunciate window shall have two LED lights connected in parallel which operate at not more than 75% of their rated voltage. Window shall be arranged in a logical group. The annunciate shall have a module construction with glass epoxy plug in cards.

Electronic hooter / Alarm bell / siren shall be continuously rated, The Annunciator shall have the following facilities:
(a) First in sequence, memory reset.
(b) faults shall be memorized.
(c) Test Feature.

There shall be a three tier system of protection and annunciation:

(a) Alarm both audible and visual.
(b) Warning with delayed shut down time delay through a timer of range 0-60 sec.
(c) Disturbance associated with failures of systems elsewhere with serial communication port.

6.10.15 Meters

Individual meters shall be provided for speed reference, speed feedback, current reference, current feedback, pulse output, and regulated power supply voltages.

All meters shall be identical and fed through individual buffer IC amplifiers. All meters shall be the circular scale type having a full scale deflection of 270deg. All meters shall conform to at least accuracy class 1.0

All meters with their individual buffer amplifier cards shall be housed in separate bin. It shall be recommended that the buffer amplifiers all be housed on a single/two cards and this cards be itself/themselves housed in the regulator bin.

Sensitive signal leads in that case shall not have to traverse from one bin to another, only noise insensitive buffer amplifier output leads shall need to go to the meter bin. Selector switches if used with any meters shall have pistol grip handles.

6.10.16 Wiring

Stranded, flexible copper cable of2.5 sq.mm shall be used for CT circuits and 1.5 sq.mm for other control circuits. However for PCB terminals 0.75 sq.mm tinned copper wire may be accepted.

Ultra-flexible cables shall be used for all connections from a fixed part to a movable member. In addition, a hanging loop of sufficient length shall be provided to avoid any cable stressing.

All terminal boards for outgoing connections shall be at a height of at least 250 mm from the cubicle floor, and preferably tilted at an angle of 45^0 to the horizontal for ease of connections. Similarly, connection of the incoming power cables to the bus bars shall be done at a height of at least 250 mm from the cubicle floor.

Item designation and location marking shall be in line with IEC recommendations.

Device labelling shall be on its fixed mounting and not on the device itself such that labelling remains even when the device shall be replaced. Metallic labels/paper labels or sticker shall be accepted.

6.11 Electrical Motors

6.12.1 General

Electric motors shall comply with IS 325, BS 4999 and BS 5000, IEC 60034, IEC 60072 and IEC 60085 and shall be bi-directional and rated on the basis of duty type S1 (maximum continuous rating).

Where the power supply permits motors shall be preferentially of the 3 phase type. Motors shall be suitable for two starts in succession from hot under the specified duty conditions of load torque and inertia and shall also be suitable for six equally spaced starts per hour under similar conditions.

Motors shall be designed to operate on the supply voltage specified for the Works. Motors shall be capable of operating under conditions of three phase supply imbalance where the negative and zero

phase sequence components of the voltage do not individually exceed 2% of the positive phase sequence components.

6.12.2 Construction

Motor construction shall provide a degree of protection as follows:
IP 54 - internal use including applications in dusty environments.
IP 65 - external use in exposed location.
Motor mounting arrangement shall be to suit application.

Motor cooling shall be totally enclosed fan cooled. Other forms of ventilation may be used with the approval of the Engineer.

Motor bearings shall be provided with facilities to add additional lubricant. For grease lubricated bearings grease nipples shall be provided and a grease relief feature incorporated. Oil lubricated bearings shall be provided with site glasses which provide an accurate indication of bearing oil level when the motor is in use.

Motors shall be designed for normal sound power as defined by IS 325 or BS 4999 and windings shall be insulated to class F as defined by IS 11182 or BS 2757. However, temperature rise at full load shall be limited to that for Class B insulation.

Where specified motor windings shall incorporate:
Thermistors (PTC type), or
Resistance thermometers (PT 100).

In each instance the temperature detecting devices shall be in close thermal contact with each phase of the stator windings. All thermistors shall be connected together to provide a single electrical circuit for connection to an external relay which shall be capable of tripping the motor.

Each resistance thermometer shall be connected separately to an external monitor relay which shall offer alarm and trip settings. Thermal protection shall be Class I for sizes of motor upto 75kW and Class II above 75kW.

All motors (rating 7.5kW and above) shall be fitted with anti-condensation heaters. A warning label, black letters on a yellow background shall be fitted to indicate that the heater may be energised. Heater terminals shall be shrouded on larger motors a separate terminal box shall be provided.

Anti-condensation heaters shall be sized to raise the temperature inside the motor several degrees above the dew point temperature, the heater surface temperature should not exceed 200°C. Heaters shall be automatically disconnected when the motor shall be switched on.

6.12.3 Performance and Characteristics of LT Motor

(i) Motors shall be capable of giving rated output without reduction in the expected life span when operated continuously under either of the following supply conditions:

Supply Condition
(a) Variation in supply voltage
From rated voltage +10%, -10%
(b) Variation in supply frequency

from rated frequency +5%

(c) Combined voltage and
Frequency variation +/-10%

(ii) All Motors shall be suitable for the method of DOL starting.

(iii) The minimum permissible voltage shall be 90% of the rated voltage during motor starting.

(iv) Motors shall be capable of starting and accelerating the load with the applicable method of starting, without winding temperatures reaching injurious levels, when the supply voltage shall be in the range of 90% of the rated motor voltage to maximum permissible voltage.

(v) The locked rotor current of the motor shall not exceed 600% of full load current (subject to tolerances as per the applicable standard) unless otherwise specified. The locked rotor current of VFD controlled motor shall be within the limit of IS12615 / IEC.

(vi) Motors shall be capable of developing the rated full load torque even if the supply voltage drops to 70% of the rated voltage. The pull-out torque of the motor shall be atleast 205% of full load torque.

(vii) Motors when started with the driven equipment coupled shall be capable of withstanding at least two successive starts from cold conditions & one start from hot condition without injurious heating of windings. The motors shall also be suitable for three equally spread starts per hour under the above referred supply conditions.

(viii) Motors shall be of Energy Efficient type.

(ix) LT motors should have following provision:

(a) For Motor >=7.5 KW space heater shall be provided which shall be thermostatically controlled.

(b) Vibration monitoring system shall be provided for measuring vibration in motor body and bearing for Motors >=75 KW.

6.12.4 Specific Requirements of VFD Driven Motors

The motor shall be suitable for operation with a solid-state power supply consisting of an adjustable frequency inverter for speed control. The motor shall be suitable for the current waveforms produced by the power supply including the harmonics generated by the drive. The Motor shall be designed to operate continuously at any speed over the range of rated speed.

The permitted voltage variation should take into account the steady state voltage drop across the AC drive and all other system components upstream of the motor. The motor shall be constructed to withstand torque pulsations resulting from harmonics generated by the solid-state power supply.

The driven equipment manufacturer shall be solely responsible for proper selection of the motor for the given load application and the output characteristics of the driven equipment

6.12.5 Local Push Button Station

For all motors Local Push Button station shall be supplied. For local control of motors, LPBS shall be provided suitable for wall/pedestal mounting. The Local Push Button station shall be complete with all the indication lamps, pushbuttons and shall have the specifications as listed below.

The degree of protection for LPBS shall be IP55 with canopy for outdoor and IP54 for indoor applications. The enclosure shall be made of 2 mm CRCA sheet steel and the interior and exterior of push button stations shall be painted light grey with shade no 631 of IS:5 as per TSL standards.

Minimum Push button for ON/OFF/E-Stop and Local / Off / Remote Selector Switch and indication lamps (ON/OFF/TRIP) should be provided. Reverse push button shall be provided for bi-directional

motors. The Emergency push button shall be of red mushroom head, press to lock & turn to release type.

All push buttons shall be provided with 2 nos NO and 2 nos NC contacts for various interlocking purposes. One contact of stop PB shall be directly wired to the switchgear module for direct tripping and another contact to control system.

The stations shall have sufficient number of terminal blocks with 20% spare. The wirings shall be done with 1.5 Sq.mm, multistrand copper, 1.1KV grade PVC insulated, grey colour, highly flexible wires having ends provided with identification ferrules and crimped tinned copper logs. Suitable plugs are to be provided to seal the unused cable entry opening. The glands shall be double compression brass type and shall be weather proof. The local Push button shall be mounted at 1200mm from the floor level.

The PB station shall be suitable for wall or structure mounting, provided with labels, earthing terminals, suitable lugs glands.

PB station shall be of one of the following types

Type A - Three PB's forward-reverse-Stop for reversible motors.
Type B - Two PB's start-stop for non-reversible motors.
Type C - One PB STOP for emergency.

6.12.6 Cable Terminations

Cable termination boxes shall be suitable for air termination of cables. They shall be sealed with a neoprene gasket to provide dust and weather protection.

Cable boxes for voltages in excess of 1000 shall be treated with anti-tracking varnish.

6.12.7 Junction Boxes

For LT motors of 18kW and above, power junction boxes shall be provided where 3 core aluminium shall be terminated, and copper flexible cables shall be taken from it to the motor terminals.

The degree of protection for JB shall be IP65 for outdoor and IP54 for indoor applications with 20%spare terminals.

6.12 Cables: HV, LV Power, Control and Telecommunications

6.13.1 Applicable Standards

The cables shall conform to the latest applicable standards specified below

PVC insulated cables (for voltage upto 1100V)	:	IS:694
HRPVC & PVC insulated cables heavy duty	:	IS:1554
Cross linked polyethylene insulated PVC sheathed cables (XLPE)	:	IS:7098
Low frequency cables and wires with PVC insulation and sheath	:	IEC:60189-1 & IEC-60189-2
PVC insulation and sheath of electric cables	:	IS:5831
Polyethylene insulation and sheath for electric cables	:	IS:6474

Conductors for insulated electric cables	:	IS:8130
Methods of test for cables	:	IS:10810
Specification for drums of electric cables	:	IS:10418
Specification for PVC insulated cables for electricity supply	:	BS:6346
Specification for PVC insulation and sheath of electric cables	:	BS:6746
Installation of Cables	:	IS:1255

6.13.2 Features of Construction

(a) XLPE Insulated HV all aluminium stranded Power Cables:
The Cables shall be 11kVunearthed grade, heavy duty, stranded aluminium Conductor, XLPE Insulated, Conductor Screening by extruded. Semiconducting compound, insulation screening through combination of semi conducting compound and non-magnetic tape(Copper tape), inner sheath over laid up cores, galvanized steel wire /strip armoured (Aluminium wire armouring for single core cables), outer sheath of extruded black PVC Compound type ST-2 Core Identification shall be by printed numerals.

(b) LT Power Cables
XLPE Insulated Cables:
The Cable shall be 1.1KV Grade, heavy duty, stranded aluminium above 6sq.mm, Copper Conductor 6sq.mm and below, XLPE, insulated, inner sheathed, galvanized steel wire / strip, armoured, extruded black PVC Compound type ST2 outer sheathed.

(c) Control Cables:
The Cables shall be 1.1KV grade, heavy duty, stranded copper conductor, PVC Compound type A Insulated, galvanized steel wire/ strip armoured extruded PVC type ST1 outer sheathed.

6.13.3 Cable Rating

The Contractor shall ensure that cable and wires associated with the distribution and control systems, plant wiring and all other installations throughout the works are adequately rated for their use.

In assessing the rating of any cable or wire, the following factors shall be taken into account: upply voltage and frequency:

- Maximum voltage drop permissible.
- Type and magnitude of load.
- Fault level and duration related to circuit protection relays and fuses.
- Circuit overcurrent protection.
- Route length and disposition of cables.
- Ambient temperature.
- Method of installation.

All power cables shall be sized for continuous current carrying capacity at the ambient temperature of 45^0C. The design current capacity of any circuit shall not exceed the full load current of the supplied device by at least 10%. Power cables shall be sized to limit the maximum voltage drop to not more than 3%.

Under motor starting conditions the corresponding voltage drop shall not affect the operation of the motor controls or the ability of the motor to start and run effectively and in any event shall not exceed 10%. The Contractor when sizing cables for the remote operation of shunt trip coils shall take due account of the voltage drop caused by the momentary current surge taken at the instant of energisation. HV and LV cables shall be sized for a fault clearance time of 1 second for the incoming feeders and 0.5 second for switchboard feeders controlled by circuit breaker.

6.13.4 Cable Colours

All cable cores shall be colour coded throughout their length and shall be so connected between switchboard, distribution board, plant and accessories, that the correct sequence or phase colours are preserved throughout the system.
The colour coding should be as follows:

3 phase	red, yellow and blue
single phase or dc	red and black
earth	green /yellow
control	blue (dc), red (ac)

6.13.5 Cable Conductors

Copper conductors shall be used for cables of sizesupto6 Sq.mm and above6 Sq.mm Aluminium conductors shall be used. Cores of cross-sectional area greater than 1.5Sq.mm shall be stranded. Lighting final distribution circuits shall be of a minimum cross-section of 1.5 Sq.mm. Power cables shall be of a minimum cross-section of 2.5 Sq.mm. Internal wiring of control panels shall be of a minimum cross-section of 1.0 Sq.mm flexible and stranded Control cables shall be of a minimum cross-section 1.5 Sq.mm for external use and 1.0 Sq.mm for internal use.

6.13.6 Cable Numbering

All cables shall be allocated a unique number which shall be fixed to each end of the cable using a corrosion resistant label. Cables of different categories shall be tagged with the following subscripts and three digit number

HV power	HV-P_ _ _
LV power	P_ _ _
Control	C_ _ _
Instrumentation	I_ _ _
Protection	PR_ _ _

6.13.7 Cable Drums

Cables shall be supplied in non-returnable wooden drums. The wood used for construction of the drum shall be properly seasoned and free from defects and wood preservative shall be applied to the entire drum. All ferrous parts shall be treated with a suitable rust preventive coating to avoid rusting during transit or storage.

The Bidder shall indicate in the offer, the maximum length for each size of cable, which can be supplied on one drum. The actual length supplied on each drum shall be within tolerance limit of ± 5% without any tolerance on total ordered quantity of each size of cable. However, before winding the cables on drums contractor shall obtain Employer's approval for the drum lengths.

Each drum or coil of cable shall be accompanied by a certificate stating the manufacturer's name, cable size and number of cores, length, result and date of tests as required in the Employer's Requirements. Cables manufactured more than 12 months before delivery shall not be accepted. All cables shall be delivered with cable ends effectively sealed by hygroscopic scaling caps. When a cable is cut from a drum both ends shall be immediately sealed to prevent ingress of moisture. Cables shall not be transported to site in loose coils but a number of short lengths of cable may be transported on the same drum. The Contractor shall be wholly responsible for the purchase and/or hire costs of all cable drums and for the removal of these drums from site after use.

6.13.8 Cable Installation

General

Cables shall be installed in such a way that the minimum bending radii are not reduced when installed or during installation. Cables shall not be installed in ambient temperatures below that recommended by the cable manufacturer.

Cables grouped together shall have insulation capable of withstanding the highest voltage present in the group.

Cable fire sealing shall be provided such that fire proof cable penetration seals rated for two hours shall be provided as per BS: 476 (Part - 20) or equivalent standards.

Cables of different categories shall be installed so as to maintain satisfactory clearances for safety and in order to reduce the possibility of electrical interference. The following table details the distances in mm that shall be maintained between the different categories of cable.

Table of Separation Distances in mm between different Categories of Cable

Cable Category	HV Power	LV Power	C&I/Protection
HV Power	N/A	300	500
LV Power	300	N/A	300
C&I/Protection	500	300	N/A

These separations are minimum and special circumstances such as the presence of high current flows, or harmonic content may necessitate larger separation distances.

In order to make economic use of the cable support system, cables shall be arranged in groups of 50 mm maximum overall diameter. These groups shall be securely tied to the cable support system at intervals not exceeding 900 mm for horizontal runs and 300 mm intervals on vertical runs.

Cables shall be laid in a manner such that any electrical interference between cables shall not have a detrimental effect on the life and operation of Plant.

Where practical a separate cable support system shall be provided for power and non-power cables. Where this is not practical a separation of 150 mm shall be maintained between power and non-power cables when run on the same support system.

Heavy duty galvanized iron cable tray and ladder racking shall be used for cable support systems. Plastic or GRP cable support systems shall be used in areas used for the storage and handling of chlorine. These systems shall be used to route cables around walls and within cable trenches. Cables

shall be securely fixed to the support systems Bundling of cables shall be permitted where allowance for this practice has been made in sizing the cables.

6.13.9 Cables Laid Direct in Ground

Buried cable up to 650/1100V shall have a minimum cover of 500 mm measured to the top of the highest cable. On crossing roadways the cable shall be run through a PVC-U duct of minimum diameter 100 mm with a minimum of 1000 mm cover and encased on all sides by 150 mm of concrete. Cables of greater than 650/1100V shall be buried with a minimum cover of 1 m.

The bottom of the cable trench shall be freed of sharp stones and such like and 75 mm of sieved sand laid below the cable. After cable laying 75 mm of sieved sand shall be laid above the cable. Interlocking cable protective covers, minimum 1 m long x 300 mm wide, marked 'Danger -Electric Cable' in English and the vernacular shall be laid on top of the sieved sand covers shall extend the whole length of the cable trench and shall overlap cables by a minimum of 50 mm. Warning tape shall be laid a minimum of 200 mm above the protective covers. Cables are to be installed without tees or through joints unless otherwise approved by the Engineer Single core cables shall be run in trefoil formation.

6.13.10 Cables Laid in Underground Ducts

Underground ducts shall be constructed of impact resistant PVC-U and laid at a minimum depth of 500 mm, ducts shall be surrounded by at least 75 mm of sieved sand except at road crossings where it shall be 1 m deep and encased on all sides by 150 mm of concrete.

The Contractor shall ensure that sufficient draw-in points have been provided and that adequate room has been allowed for installation of cables. Drawstrings shall be provided in all ducts to enable additional cables to be installed when required.

Where cables pass in or out of any duct entries into or within buildings such entries, together with any spare ducts shall be sealed against the ingress of moisture by means of duct stoppers and bituminous compounds or by any other method approved by the Engineer. The stopper shall have a fire resistance of at least 30 minutes. Single core cables in trefoil formation shall pass through the same duct and shall not be separated.

6.13.11 Cables installed in Conduit

(a) General

Conduits shall be galvanized heavy gauge solid drawn or welded screwed steel type and be in accordance with IS 9537 Part 2 or BS 4568. Accessories shall either be malleable cast iron screwed type or pressed steel and galvanized.

A space factor of 40% shall not be exceeded, but in any case, conduit of less than 20 mm diameter shall not be permitted. The tubing shall be perfectly smooth inside and out and free from flaws and imperfections of any kind. Both ends of every length of tubing shall be properly reamed with all sharp edges removed before erection.

Where several conduits converge, malleable cast iron or heavy gauge sheet steel adaptable boxes shall be employed in order to avoid crossings. Conduits shall be connected by means of male brass bushes and couplings.

Where conduits are greater than 25 mm, straight through joint boxes shall be of the trough type. Where conduit and/or fittings are attached to equipment casings, the material or case of the casing shall be tapped for a depth of not less than 10 mm or male bushes and flanged couplings shall be used.

Heavy hexagonal lock nuts shall be used at all positions where running joints are required and great care shall be taken to ensure that they seat firmly and evenly on to the mating faces of coupling or other adjacent accessories. All junction boxes, draw-in boxes, and inspection fittings, shall be so placed that the cables can be inspected and, if necessary, withdrawn and re-wired throughout the life of the installation.

Generally not more than two bends or offsets or one coupling shall be permitted without a suitable inspection accessory. Fish wires shall not be left in conduits after erection. The whole of the installation shall be arranged for a loop-in type of system with joints being carried out at switches, isolators, etc Intermediate joints in the cable shall only be allowed by arrangement with the Engineer. Where terminal blocks are necessary, they shall be of the porcelain type with brass pinching screws.

Ends of conduits which are liable to be left open for any length of time during building operations shall be plugged to prevent the ingress of dirt, cement, etc and covers, either temporary or permanent, shall be fitted on all boxes.

Generally, conduits shall not cross expansion joints of buildings, but where they cannot be installed in any other manner then a flexible conduit shall be used across the expansion joint A total 150 mm movement shall be allowed.

(b) Surface Installation

Surface conduits shall be secured and fixed by means of distance spacing saddles or approved purpose made clips which allow the conduits to be taken directly into accessories without sets or bends. Conduits shall be run in a square and symmetrical manner. An efficient means shall be adopted to provide for the drainage of condensation and the runs shall be properly ventilated.

All surface conduit runs shall be marked out for approval by the Engineer before the installation shall be carried out. Where large multiple parallel conduit runs would occur, use may be made of galvanized cable trunking. Conduits installed on structural steelwork shall be secured at spacing not exceeding those for surface conduit by girder clips, otherwise fixing shall be as for surface conduits on walls, drilled and tapped to the metalwork Power driven fixings shall only be used with the express permission of the Engineer. Any drilling or access which shall be required through any structural member of the building shall be agreed with the Engineer before carrying out the work.

Exposed threads and places where galvanizing has been damaged shall be cleaned and then painted with two coats of an approved metallic zinc based paint. This treatment shall be applied as the work proceeds.

(c) Concealed Installation

Concealed conduits shall be securely fixed to prevent movement before laying of screeds, floating of plaster, casting of columns or other building operations necessary after the conduit installation. Crampets or similar fixings shall be used for attaching the conduit to brick work, etc. Building nails shall not be accepted.

At least 15 mm cover shall be allowed for finishes over the conduit. Where this cover cannot be maintained then expanded metal shall be fitted with the conduit. Conduit cast into reinforced concrete floors shall be fixed to the steel reinforcing with binding wire and the conduit boxes filled with

expanded polystyrene or enclosed in a plastic bag to prevent the ingress of concrete when poured. Where possible, the conduit boxes shall be fixed to shuttering to give a flush finish.

Conduit installed in voids, false ceilings, and other concealed routes shall be installed as specified for the surface conduits. Wiring shall be carried out after the false ceiling or permanent ducts have been completed. Conduit installed in floors shall be sealed against ingress of moisture.

The conduit installation shall be inspected by the Engineer before the building operation conceals the work.

6.13.12 Cable Installed in Flexible Conduit

Flexible conduit shall be of the waterproof galvanized type or PVC wire-wound type with cadmium plated mild steel couplings. Lengths of flexible conduits shall be sufficient to permit withdrawal, adjustment or movement of the equipment to which it shall be attached and shall have a minimum length of 300 mm. Flexible conduit shall not be used as a means of providing earth continuity. A single earth conductor of adequate size shall be installed external to the conduit complete with earth terminations.

Where conversion from rigid conduit to flexible metallic conduit shall be made, the rigid conduit shall terminate in a through type box and the flexible conduit shall extend from this box to the equipment, the earth continuity cable shall be secured to the box and to the piece of equipment by properly designed earthing screws. The use of lid facing screws, etc. shall not be permitted. Adapters shall incorporate a grub screw or a gland to prevent the flexible conduit becoming loose.

6.13.13 Cable Installed in Cable Trunking – Metal

Cable trunking shall be manufactured from mild steel of not less than 125 mm and shall be hot dipped galvanized. The Contractor shall ensure that the size of the trunking shall be adequate for the number of cables to be installed together with 50% spare capacity and shall in any case be 50mm x 50 mm minimum size.

Segregation of cables shall be carried out if required using continuous sheet steel barriers with the bottom edge welded to the trunking.

The trunking shall have two return flanges for rigidity. Where necessary, additional strengthening straps shall be fitted internally. The cover shall overlap the trunking and be made of the same gauge. Fixing screws for covers shall be recessed and be of the self-retaining `quick fix' type. All bends, tees and intersections shall be of the gusset type and shall, wherever possible, be purpose made by the manufacturer and of a matching design to the main trunking.

Cables shall be retained in the trunking when the cover shall be removed by means of straps. Internal connecting sleeves shall be fitted across joints in the trunking and earth continuity ensured by bonding each section of trunking to a continuous earth wire.

Non-flammable fire barriers shall be inserted where the trunking passes through walls or floors. Conduit connections to trunking shall be made by flanged couplings and male bushes. Trunking shall be supported at intervals not greater than 2 m horizontally or 25 m vertically. Crossings over expansion joints shall be made in flexible conduit.

Should it be necessary to cut or drill a section of trunking or a trunking fitting the bared ends shall immediately be given a coat of zinc rich cold galvanizing paint.

Cable and conduit / trunking runs shall be determined by the Contractor and agreed by the Engineer before any work shall be started. The run shall be at least 150 mm clear of plumbing and mechanical services. Conduit / trunking systems erected outside a building shall be weather proof.

6.13.14 Cable Installed on Cable Tray

Cable tray shall be of perforated sheet steel with formed flanges and of minimum thickness not less than 1.5mm for trays up to 100mm width, perforated/ladder type with minimum thickness not less than 2mm for trays above 100mm to 300mm width and 2.5mm for trays above 300mm width. Exterior perforated cable trays shall be covered with cable tray covers.

Cable tray shall be hot dipped galvanized. Cable tray for use in areas where chlorine gas may be present shall construct from U-PVC or GRP Cable tray supports shall be of a compatible finish with the associated cable tray.

All cable tray tees, intersection units, bends, turns and sets shall, whenever possible, be purpose made by the manufacturer and shall be of a matching design to the main section of cable tray.

Tray shall only be joined by couplers supplied by the manufacturers. The joint shall be secured in accordance with the manufacturer's instructions.

Cable tray supports supplied by a manufacturer or made up on site shall be of ample strength to maintain rigid support to the fully laden cable tray along its entire length and shall ensure that the deflection of any one section does not exceed 15 mm at mid-span.

Wherever possible, cable trays shall be installed in full lengths without cutting. Should it be necessary to cut or drill a length of tray, then for galvanized trays, the bared ends or damaged section of the tray shall immediately be given a coat of zinc rich cold galvanized paint. All site manufactured accessories, supports and metal fittings required to ensure correct installation of the cable trays shall be similarly treated.

All cables shall be firmly secured to the tray using purpose made saddles, as approved by the Engineer, together with proprietary nylon fasteners and/or cable cleats. Following installation of cables, the tray shall remain rigidly supported and the deflection of any section shall not exceed 15 mm at mid-span. All brackets and tray work shall be suitable for withstanding a temporary weight of 125 kg.

Cable trays shall not be cut to allow the passage of cables through the surfaces of the tray. The sizing of the cable tray shall provide a minimum of 25% spare capacity. The tray shall be run at least 150 mm clear of plumbing and mechanical services.

6.13.15 Cable Installed on Ladder Rack Systems

Ladder racking either light or heavy weight shall be proprietary item and installed in accordance with manufacturer's instructions. Bends in the installation shall take account of the minimum bending radii of cables to be installed. Cables shall be clipped to the ladder rack using clips designed for the system in use and appropriate to the type and size of cable installed. The sizing of the cable rack system shall

provide a minimum of 25% spare capacity. The ladder racking shall be run at least 150 mm clear of plumbing and mechanical services.

6.13.16 Cable Clipped Direct

All cable hangers, clips, cleats and saddles shall be of an approved type and appropriate to the type and size of cable installed. Their spacing shall be such as to ensure a neat appearance and prevent sagging of the cables at all times during their installed life.

6.13.17 Cable Installed in Internal Floor Trench

(a) In Shallow trenches (maximum depth 500 mm)
In shallow trenches used for electrical services only, cables may be laid in a neat and orderly manner on the floor of the trench. One layer only shall be allowed. Additional cables shall be installed on the walls of the trench in an approved manner. Here the trench shall be shared by other services, cables shall be installed on the walls of the trench in an approved manner.

(b) All other trenches including walk through service ducts
Cabling shall be installed to the walls of the trench in an approved manner. Where other services are present the cables shall be segregated from them and wherever possible kept above 'cold' 'wet' services. Cables should not be run if at all possible, above or in close proximity to 'hot' services. The cabling shall be installed in such a manner as to allow access to the other services for normal maintenance without disturbance of the electrical installation.

6.13.18 Cable Terminations and Joints

(i) **Power Cable Terminations**
Power cables shall be terminated in suitable boxes arranged for bolting to switchgear, motor starters and motors. Cores shall have either crimped lugs or sleeves to match either post terminals or bolted clamp terminals.

Each cable entry into a terminating box shall be made through a suitable gland, which shall have provision for securing the armour where applicable. Where single core glands are required these shall be of the non-magnetic type and the associated box bottom plate, where the core passes through, shall not have a continuous magnetic path.

Adequate provision shall be made to bond the cable armouring to the box and/or switchgear casing of a suitable size to withstand the prospective short circuit fault current of the system, glands shall be fitted with earth bonding tags where intimate screwed contact between gland and cable box shall not be possible.

Where cable glands are exposed to the weather these shall be protected by heat shrink plastic sleeve or purpose moulded sleeves covering the gland continuously from overall sheath to the gland neck.

Where terminations of multicore type have to be made on to items of plant which have to be dismantled for maintenance, these shall be made off through glands into an adaptable box containing terminals and flexible single cores taken into the equipment via flexible waterproof plastic covered conduit, and a separate earth core linking the box to the equipment.

Where cables are glanded to or pass through cabling plates the gland plate or cabling plate shall be constructed of non-magnetic material.

(ii) Power Cable Joints

Through joints shall only be allowed with the approval of the Engineer. Where such joints are necessary in thermoplastic and elastomeric cables, the cables shall be jointed with epoxy or acrylic resin cold setting compound, which has been premeasured and pre-packed ready for use. The boxes shall preferably be of split, moulded plastic type with filling vents for compound. Bonding straps shall be fitted with armour clamps across the joint and inspected by the Engineer prior to filling the box with compound. Wrapped pressure type joints shall not be accepted. In case of HT cable end termination and straight through joints shall be approved heat shrinkable type. High voltage test shall be conducted, and test reports and megger values shall be submitted after test along with calibration certificates of the instrument used for measuring.

(iii) **Multi core or Control Cable Terminations**

A sufficient number of terminals shall be provided to terminate all cable cores including 10% spare cores. For control and auxiliary wiring an additional 20% of this number shall be provided as spares.

Not more than one core of internal or external wiring shall be connected on any one terminal. Where duplication of terminal blocks are necessary, purpose-made solid links shall be incorporated in the design of the terminal blocks.

Terminals which remain energized when the main equipment shall be isolated shall be suitably screened and labelled.

Terminal blocks for different voltages or circuit type shall be segregated into groups and distinctively labelled.

6.13.19 Cable Fixings

Ties and strapping shall be suitable for securing cable and cable groups to cable tray or ladder. They shall be resistant to chemical and marine corrosion Plastic coated metal ties used in order to obtain corrosion resistance shall not be acceptable. Nylon ties shall be resistant to the effects of ultra-violet light and shall be self-extinguishing. Large single cables shall be secured with cable clamps or cable cleats.

Cable Identification

At each end of each cable, in a uniform and visible position a label shall be fixed on the cable in accordance with the cable schedule. Labels shall be made of PVC and shall be indelibly marked to the approval of the Engineer. The label shall be retained using proprietary nylon strips passing through two fixing holes at either end of the label. If the cable gland shall not be normally visible, then the label shall be fixed inside the panel by means of screws.

6.13.20 Cable Glands

Glands shall generally be of the mechanical double compression hexagon type Earth continuity of brass glands shall confirm to BS: 6121/ EN 50262.This may be achieved by the rigid clamping of the armour within the gland and the intimate contact between the threaded components of the gland and the equipment.

Each gland shall be installed complete with proprietary earth tag providing a ready means of connecting a flexible strand or strip earth bond to the gland at any position around the gland in relation to the associated apparatus. Adequate earth continuity shall be assured between the earth tag, the gland and the armour wires of the cable where applicable.

Glands for single core cables shall be constructed from non-magnetic materials. Each gland shall be installed complete with a proprietary non-ferrous lock-nut to secure the gland body to the equipment where the entry hole is plain, i.e. not tapped. Where holes for cable entries are not provided it shall be the responsibility of the contractor to mark out and drill such holes Burrs and swarf shall be removed, care being taken to ensure that swarf and filings, etc do not enter the equipment.

For non-hazardous areas cable glands in situations where moisture may be present shall be double seal weatherproof type, gland shrouds shall be used, and entry shall be sealed. For dry indoor situations, standard industrial glands with shrouds are acceptable. For hazardous areas, glands conforming to EExd standard shall be used with double seal and shroud.

Power cable glanding arrangements in hazardous areas shall incorporate an insulated adapter and earth link. This shall provide the facility to disconnect the armouring from the glanded device in order that a true earth loop value may be measured when carrying out tests on the installation. Cable Glands shall be suitable for indoor and outdoor use, appropriate for single wire armoured, plastic or rubber sheathed cable. Which provides grip to the cable with outer and inner seals suitable for all climatic conditions weatherproof and waterproof. The outdoor cable glands shall be provided with shrouding.

Marking Locations of Underground Cables

The location of all underground cables shall be engraved on brass or other non-corrodible plates to be fixed to the exterior surface of all walls of buildings 300 mm above ground level and directly above the point where cables pass through the wall.

In addition, concrete route marker posts shall be installed at intervals of not more than 50 m at all junctions and changes of direction along the cable route and cable joint markers shall be provided where ever undergrounding cable joint exists. Such marker posts shall be not less than 200 mm high and of substantial construction.

A drawing or sample of a typical marker post shall be submitted for the approval of the Engineer. The markers shall be marked ‘electric cable’ / ‘cable Joint’ in English and the vernacular.

6.13.21 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc, shall be submitted along with the bid/ after award of contract as specified under, “Bid/Contract Drawings”, Part 3, General Requirements, Volume-2 of Bid Documents.

6.13 Cable Carrier System

6.14.1 General

The cable carrier system covers the supply of cable racks, cable trays and its supporting accessories.

6.14.2 Applicable Standards

Steel for general structural purposes	:	IS:2062
Dimensions for hot rolled steel beam column channel and angle sections	:	IS:808
Code of practice for use of metal arc welding for general construction in mild steel	:	IS:816

Hot deep galvanizing of iron & steel	:	IS:2629
Methods of testing uniformity of coating of zinc coated articles	:	IS:2633
on structural Hot dip zinc coatings steel and other allied products	:	IS:4759

Cable Racks, Trays and their support structure

(a) Typical cable tray arrangement/trench arrangement/directly buried cable arrangement etc are shown in Volume -4, Typical Drawings.
Cable racks/trays shall be fabricated from standard structural steel members.

(b) All cable trays, vertical raceways, cable racks and cable tray supporting structures shall be hot dip galvanized.

6.14.3 Galvanising

Wherever galvanizing has been specified, the hot dip process shall be used. The galvanized coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

(a) Fabricated Steel	
Thickness less than 2 mm, but not less than 12 mm	340 gms/sqm
Thickness less than 5 mm, but not less than 2 mm	460 gms/sqm
Thickness 5 mm and over	610 gms/sqm
(b) Fasteners	
Up to nominal size M10	270 gms/sqm
Over M10	300 gms/sqm

Galvanizing shall be carried out after all drilling, punching, cutting, bending and welding operations have been carried out. Burrs shall be removed before galvanizing. Any site modification of galvanized parts such welded joints, fabricated cable trays and supports should be covered well by zinc rich primer and aluminium paint.

6.14.4 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified under, “Bid/Contract Drawings”, Part 3, General Requirements, Volume-2 of Bid Documents.

6.14 Lighting System

6.15.1 General Requirements

LED lighting shall be considered for indoor and outdoor lighting. Conventional lighting shall be considered subject to the requirement and approval of Employer. However general requirements of conventional lighting along with LED lighting have been described in the following sections.

(a) The Lighting system includes the following items
(i) Lighting fixtures complete with Lamps and accessories (lumen per watt shall be indicated).
(ii) Lighting system equipment (ISI make).
- Light control switches, receptacle units with control.
- Switch units, lighting wires, conduits and other similar items necessary to complete lighting system.

- Lighting fixture supports, street lighting poles and flood light towers.
- Main Lighting distribution board, lighting panels.
- Multi core cables for street, boundary and flood lighting.

(b) DC Emergency Lighting shall be provided for substation room, SCADA room, Switchgear room and Carridors. Load balancing of lighting system shall be made.

(c) High Power White LEDs are used in the luminaries and the Wattage of these LEDs would be greater than ONE watt.

(d) LED shall be operated at a forward current of less than 90% of the rated current.

(e) Colour Rendering Index (CRI) of the LEDs used in the luminaire shall be greater than 70.

(f) The illumination of the luminaries shall be uniform without dark bands or abrupt variations and soothing to the eye.

(g) Light Uniformity Ratio (E min / E avg) would be > 0.4.

(h) Luminary Body Temperature would be less than 30 deg C above the ambient, even after continuous burning of Luminary for 24 Hrs.

(i) The Luminaire works on single phase three wire system (Phase, Neutral & Earth).

6.15.2 Construction of LED luminaires

(a) The luminaire housing shall be made up of Corrosion free High Pressure Aluminium die cast thus confirming the luminaire to IP-65 protection and safety as per IEC 60598-1.

(b) The Luminaire shall be equipped with distortion free, clear, Heat Resistant toughened, UV stabilized glass cover in the front fixed to the die cast Aluminium frame which would be fixed to the housing by means of stainless steel screws.

The minimum technical specifications for LED lighting shall be as follows:

(i) Powered by the latest bright LEDs with high efficiency and meeting LM-80 standard.

(ii) Average rated life span of 50000 hrs.

(iii) LED lumen output shall be greater than 125 Lumens/watt.

(iv) Luminaries lumen output of at least 80 Lumens/watt.

(v) Input voltage range 90-300 V.

(vi) Power factor > 09.

(vii) THD < 15%.

(viii) Ingress protection as per IP 65.

(ix) Operating temperature -5°C to 50°C.

(x) Storage temperature -5° to 70°C.

(xi) Humidity 10% - 100%.

(xii) LEDs shall be operated at a forward current less than 90% of its rated current.

(xiii) The LEDs used in the luminaire shall have minimum angle of 120 degree.

(xiv) Colour rendering index (CRI) of the LEDs shall be greater than 70.

(xv) Conform to Photo Biological Safety for the LEDs as per IEC 62471.

(xvi) Free replacement warranties of 5 years for technical defects.

6.15.3 Applicable codes & standards

(a) 2006/95/EC, Low Voltage Directive (LVD).

(b) 2004/108/EC, EMC Directive.

(c) IS 1944 (Part 1& 2): 1970/ Code of practice for lighting of public thoroughfare.

(d) EN 50530, IEC 62124, IEC 61347-2-13, IEC 62384, CISPR 15, IEC 61547, IEC 60598

6.15.4 Tests

Contractor shall submit all following test reports for LED lighting fixtures before dispatching of material at site. All tests shall be carried as per IES approved methods defined (LM-82)

(a) Lm-80 for measurement of lumen of LED source.
(b) LM-79 for fixture-Electrical & Photometric measurement.
(c) TM-21 test for LED life.
(d) Thermal Characteristic- Test for Lumen output temperature dependency.
(e) Electrical Characteristic- Test for the calculation of efficacy.
(f) Driver testing for Power factor, THD & Isolation.
(g) IP Protection test against ingress of duct & solid objects for both indoor & outdoor LED fixtures.

6.15.5 Earthing

(i) Each luminaire shall be provided with an earthing terminal suitable for connection to the earthing conductor of 12 SWG GI wire.
(ii) Where separate control gear box shall be provided for housing the accessories the same shall be provided with an earthing terminal suitable for connecting earthing conductor of 12 SWG GI wire.
(iii) All metal or metal enclosed parts of the luminaire/control gear box shall be bonded and connected to the earthing terminal so as to ensure satisfactory earthing continuity.

Painting/Finish

(i) All surfaces of the Luminaire/Control gear box housing accessories shall be thoroughly cleaned and degreased. It shall be free from scale, rust, sharp edges and burrs.
(ii) When enamel finish shall be specified, it shall have a minimum thickness of 2 mils for outside surface and 1.5 mils for inside surface. The finish shall be non-porous and free from blemishes, blisters and fading.
(iii) The luminaire housing shall be stove-enamelled/epoxy stove-enamelled-vitreous enamelled or anodized as indicated under various types of fittings.
(iv) The surface shall be scratch resistant and shall show no sign of cracking or flaking when bent through 90 deg over 1/2" dia mandrel.
(v) The finish of the luminaire shall be such that no bright spots are produced either by direct light source or by reflection. External control gear box provided for housing accessories shall be painted or galvanized.

Applicable Standards

All light fittings shall be energy efficient type with lumen per watt shall be specified. The design, manufacture and performance of equipment shall conform to the latest standards specified below:

Electrical lighting fittings general and safety requirements	:	IS:1913/ BS:4533
Code of practice for industrial lighting	:	IS:6665
Calculation of co-efficient of utilization	:	IS:3646 (Part - III)
Industrial lighting fittings with metal Reflectors	:	IS:1777
Decorative lighting outfits	:	IS:5077
Dust proof electric lighting fittings	:	IS:4012
Dust tight electric lighting fittings	:	IS:4013
Flood lights	:	IS:10322/BS:4533

Luminaires for street lighting	:	IS:10322 Part 5
Water tight electric lighting fittings	:	IS:3553/ BS:4533,5225(I)
Bayonet lamp holders	:	IS:1258/BSEN 61184/IEC:60061
Edison screw lamp holders	:	IS:10276/BSEN 60238
Bi-Pin lamp holders for tubular fluorescent lamps	:	IS:3323
Starters for fluorescent lamp	:	IS:2215/BSEN 60155
Holders for starters for tubular fluorescent lamps	:	IS:3324/ BSEN 60400
Ballast for use in fluorescent lighting fittings	:	IS:1534 (Part 1)/BSEN 60920& 60921
Transistorized ballast for fluorescent lamps	:	IS:7027
Ballast for HP mercury vapour lamp	:	IS:6616
Capacitors for use in fluorescent lamps	:	IS:1569/ BSEN 61048
HPMV & LP sodium vapour discharge circuits		& 61049 /IEC:60586
Vitreous enamel reflector for tungsten filament lamp	:	IS:8017
Tubular fluorescent lamps	:	IS:2418 (Part –1) /BSEN 60081 IEC:60081
High pressure mercury vapour lamps	:	IS:9900/BS:3677/ IEC:60188
Tungsten filament general electric lamps	:	IS:418/IEC:60432
Cast acrylic sheets for use in Luminaires	:	IS:7569
Screwless terminal and electrical connections for lighting fittings	:	IS:10322
High pressure sodium vapour lamps	:	IS:9974
Emergency lighting units	:	IS:9583
Ignition proof enclosures, dust-tight for elect Equipment	:	IS:11005
Luminaires	:	IS:10322 (Part I to V)

6.15.6 Lighting System Equipment

Arrangement for busbars, main connections and auxiliary wiring and marking	:	IS:5578/ 11353/BS:159
Enclosed distribution fuse boards and Cut-outs for voltages not exceeding 1000V	:	IS:2675/ BSEN 60439
General requirements for switchgear and Control gear for voltages not exceeding 1000 V	:	IS:13947
Code of practice - installation and	:	IS:10118/BS:6423
Maintenance of switchgear	:	BS 6626, BS 6867
Factory built assemblies of switchgear and control gear for voltages upto and Including1000 V AC and 1200 V DC	:	IS:8623/BS-5486/ IEC:60439
Miniature air break circuit breakers for AC circuits	:	IS:8828/ BSEN 60898
HRC cartridge fuse links upto 650 V	:	IS:9224/BS:88/ IEC:60269
Current transformers	:	IS:2705/BS:7626/ IEC:60185
Voltage transformers	:	IS:3156/BS:7625/ IEC:60186
Direct acting electrical indicating Instruments	:	IS:1248/BS:89/ IEC:60051
AC electricity meters	:	IS:722/BS 5685
Electrical relays for power system protection	:	IS:3231/BS:142/ IEC:60255

Switches for domestic and similar purposes	:	IS:3854/BS:3676
Three pin plugs and socket outlets	:	IS:1293/BS:546
Boxes for enclosure of electrical accessories	:	IS:5133(1)
Rigid steel conduits for electrical wiring	:	IS:9537/BS:31
Accessories for rigid steel conduits for electrical wiring	:	IS:3837/BS-31
Flexible steel conduits for electrical wiring	:	IS:3480
Rigid non-metallic conduits for electrical Installations	:	IS:9537/BS:4607(2)
Fittings for rigid non-metallic conduits	:	IS:3419/BS:4607(2)
PVC insulated cables for working voltages Upto and including 1100 V	:	IS:694
Tubular steel poles	:	IS:2713
Specification for copper rods and bars	:	IS:613
Code of practice for phosphate coated iron andsteel	:	IS:6005/ BS:3189
Fittings for rigid steel conduits for electrical wiring	:	IS:2667

6.15.7 Lighting Fixtures (Luminaires-LED)

(a) Luminaires shall be designed for continuous trouble-free operation without reduction in lamp life or without deterioration of materials and internal wiring. Outdoor fittings shall be weather-proof and rain-proof type.

(b) The Luminaires shall be designed so as to facilitate easy maintenance, including cleaning, replacement of lamps/starters etc.

(c) Connections between different components shall be made in such a way that they shall not work loose by small vibration.

(d) For each type of Luminaires, the Contractor shall furnish the utilisation factor tables to indicate the proportion of the light emitted by the bare lamps which falls on the working plane.

(e) All Luminaires shall be supplied complete with lamps suitable for operation on a supply voltage with the variation in supply voltage, frequency and combined voltage and frequency of ±10%, ±5% and ±10% respectively.

Decorative Luminaires (Luminaires-LED)

(a) These luminaires shall be generally indoor type provided with cold rolled cold annealed (CRCA) sheet steel channel/rail cum reflector housing complete with all electrical control accessories mounted on it. The finish shall be stove enamelled.

(b) Decorative LED type luminaires shall be either open type, provided with translucent white opal acrylic diffusers, polystyrene lens prismatic or square polystyrene louvers

(c) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column pendant mounting or for recess mounting in false ceiling.

(d) Decorative luminaires with mirror optic reflectors shall be of the wide angle dispersion type. Where these luminaires are mounted in control rooms and computer rooms, clip-on type adjustable reflectors which can be attached onto the tube shall be provided to direct the light output in the desired direction. This shall be mainly to reduce reflection of the light source from TV/monitor screens.

(e) Luminaires mounted recessed in false ceiling shall be with reflector housing and spring loaded fixing arrangement for the diffuser/louver frame. It shall be possible to have access to the lamp and other accessories from below.

Industrial Luminaires (Luminaires-LED)

(a) The luminaire shall be provided with CRCA sheet steel mounting rail with reflector of minimum 20 SWG thicknesses and complete with all control accessories mounted on it. The finish shall be vitreous enamelled.

(b) Luminaires shall be suitable for the number of lamps of specified wattage, direct mounting on ceiling/wall/column/pendent mounting.

(c) The distribution of light shall be such that at least 80% of the total luminous flux from the luminaire shall be in the lower hemisphere.

(d) The luminous output of the luminaire with reflector shall not be less than 75% irrespective of type of reflector used

Bulk Head LED Luminaire

(a) The luminaire shall be of robust construction, with cast aluminium/vitreous enamelled housing, heat and shock resistant prismatic or clear glass cover fixed with neoprene gaskets for sealing. For mechanical protection to the glass cover, round steel wire-guard with vitreous enamelled finish shall be provided

(b) The luminaire shall be suitable for direct mounting to ceiling/wall/column and used for general purpose indoor lighting.

High, Medium and Low Bay LED Luminaires

(a) High and medium bay luminaires shall be with cast aluminium housing, anodized aluminium mirror polished reflector canopy with eye bolt for suspension, cooling fins and glass cover.

(b) The luminaire shall be suitable for up to400 / 1000 wattsLED lamps. The control gear accessories shall be mounted integral with the luminaire.

(c) High bay luminaires shall be used when the mounting height is above 8 meters while medium bay luminaires shall be used when the mounting height is around 6 to 8 meters.

Flood Light LED Luminaire

Flood light luminaires shall be of weather proof construction with cast aluminium housing, anodized aluminium mirror polished reflector, heat resistant, toughened glass cover and necessary neoprene gaskets to prevent ingress of dust

(a) The housing shall be supported on a cast iron base and capable of being swivelled in both horizontal and vertical directions and locked in any desired position.

(b) For focusing purposes, knobs, shall be provided along with sector plate indicating the angle in degrees between 0 and 90 deg in vertical direction.

Outdoor Lantern LED Luminaires

(a) Post top lantern Luminaires shall be generally outdoor weather proof type for illumination of walkways, gate posts, gardens etc

(b) The luminaire shall have cast aluminium spigot of 50/60 diameter finished with corrosion proof paint for mounting, opal acrylic or high density polyethylene (HDP) diffuser bowl, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

Sub-station Lantern

(a) Sub-station lantern shall be generally outdoor weather proof type for illumination of switchyard equipment.

(b) The luminaire shall have cast aluminium housing finished with corrosion proof paint, spigot for mounting on pole, prismatic glass refractor dome to give distribution of light in horizontal plane, anodized aluminium reflector to give light distribution at an angle 20 to 40 degrees,

above the horizontal plane, complete with integral mounted control gear, neoprene gaskets, earthing terminal etc.

Street Lighting Luminaires

(a) Street lighting LED luminaire shall be outdoor weather proof type for illumination of secondary roads, walkways, peripheral lighting of buildings etc.

(b) The luminaire shall be of semi-cut off or non-cut off type, with CRCA sheet steel housing, vitreous enamelled, plain or corrugated clear acrylic cover, complete with integral mounted control gear, neoprene gaskets, side pipe entry or top suspension type.

(c) The luminaire shall be of semi-cut off with cast aluminium housing, acrylic or prismatic cover, polished aluminium reflectors, complete with integral mounted control gear, neoprene gaskets and with rear pipe entry.

(d) The Contractor shall provide street lighting systems to illuminate all site roadways within the treatment facility areas and access road. Lux level for outdoor site shall be as per IS 1944.Outdoor lighting shall cover the perimeter portion also to focus CCTV camera at 20Lux level.

(e) The lanterns shall incorporate LED lamps with integral lamp control gear, and weather-proof body.

(f) The poles shall be sited a minimum of 1m from the road kerb edge with non-extended brackets to locate the lanterns at the kerb.

(g) The street lighting shall be fed on independent radial buried cable circuits fed and controlled from a street lighting switchboard. The cables laid for outdoor lighting application shall be wire armoured.

(h) Each circuit shall be contactor switched, controlled by an astronomical timer and manual-auto control selector switch. The contactor, time switch and manual control switch for each area shall be incorporated in the LV road lighting distribution switchboard.

Portable Emergency Light Luminaire

(a) Emergency light of installed luminaire shall be indoor type for providing emergency light during failure of normal AC supply.

(b) The luminaire shall be with CRCA sheet steel enclosure, complete with metalized mirror reflector, leak proof re-chargeable battery rated for two hour discharge, battery charger, charger-on lamp, push button switches, automatic changeover switch/relay, two meter length cord with plug, mounting pads and other accessories required for satisfactory operation of the luminaire.

(c) The luminaire shall be suitable for connection to 240 V, 50 Hz single phase supply. On failure of normal AC supply the luminaire shall pick-up automatically and on restoration of AC supply the luminaire shall switch off automatically.

(d) The luminaire shall be suitable for energy efficiency LED lamps.

6.15.8 Accessories for Luminaires

Reflectors

(a) The reflectors shall be made of CRCA sheet steel/aluminium/silvered glass/chromium plated sheet copper as indicated for above mentioned luminaires.

(b) The thickness of steel/aluminium shall comply with relevant standards. Reflectors made of steel shall have vitreous enamelled finish. Aluminium used for reflectors shall be anodized/epoxy stove enamelled/mirror polished. The finish for the reflector shall be as indicated for above mentioned fittings.

(c) Reflectors shall be free from scratches or blisters and shall have a smooth and glossy surface having an optimum light reflecting coefficient so as to ensure the overall light output specified by the Contractor.

(d) Reflectors shall be readily removable from the housing for cleaning and maintenance without disturbing the lamps and without the use of tools. They shall be securely fixed to the housing by means of positive fastening device of captive type.

Lamp holders / Starter Holders

(a) Lamp holders shall have low contact resistance, shall be resistant to wear and shall be suitable for operation at the specified temperature without deterioration in insulation value. They shall hold the lamps in position under normal condition of shock and vibration met with under normal installation and use.

(b) Lamp holders for the fluorescent lamps shall be of the spring loaded bi-pin rotor type. Live parts of the lamp's holder shall not be exposed during insertion or removal of lamp or after the lamp has been taken out. The lamp holder contacts shall provide adequate pressure on the lamp cap pins when the lamp shall be in working position.

(c) Lamp holders for induction, mercury vapour and sodium vapour lamps shall be of Edison Screw (ES) type.

(d) The starter holders shall be so designed that they are mechanically robust and free from any operational difficulties. They shall be capable of withstanding the shocks met within normal transit, installation and use.

Control switch gear electronic ballasts

(a) The ballasts shall be designed to have a long service life and low power loss. The ballasts shall be of the inductive, heavy duty type copper wire wound, filled with thermosetting, insulating, moisture repellent polyester compound filled under pressure or vacuum. Ballasts shall be provided with taps to set the voltage within the range of variation in supply voltage of ±10% of 240 V End connections and taps shall be brought out to a suitable terminal block rigidly fixed to the ballast enclosure. Ballasts shall be free from hum and such of those which produce hum shall be replaced by Contractor free of cost.

(b) Ballasts shall be mounted using self-locking, anti-vibration fixings and shall be easy to remove without demounting the fittings. They shall be in dust tight, non-combustible enclosures.

(c) Separate ballast for each lamp shall be provided in case of multi lamp luminaires, except in the case of 2 x 20 Watts luminaires.

Starters / Igniters

(a) Starters shall have bimetal electrodes / electronic igniters and high mechanical strength. Starters shall be replaceable without disturbing the reflector or lamps and without the use of any tool Starters shall have brass contacts and radio interference capacitors.

Capacitors

(a) The capacitors shall have a constant value of capacitance and shall be connected across the supply of individual lamp circuits.

(b) The capacitors shall be suitable for operation at specified supply voltage conditions and shall have a value of capacitance so as to correct the power factor of their corresponding lamps circuit to the extent of 095 lag or better.

(c) The capacitors shall be hermetically sealed preferably in a metal enclosure to prevent seepage of impregnate and ingress of moisture.

6.15.9 Galvanized Octagonal Poles for Street Lighting

The Octagonal poles shall be designed to withstand the maximum wind speed of 169 KM / Hr. as per IS 875. The top loading i.e. area and the weight of fixtures are to be considered to calculate maximum deflection of the pole and the same shall meet the requirement of BS: 5649 Part VI.

(a) Pole Shaft

The pole shaft shall have octagonal cross section and shall be continuously tapered with single longitudinal welding. There shall not be any circumferential welding. The welding of pole shaft shall be done by submerged Arc Welding (SAW) process.

All octagonal pole shafts shall be provided with the rigid flange plate of suitable thickness with provision for fixing 4 foundation bolts. This base plate shall be fillet welded to the pole shaft at two locations i.e. from inside and outside. The welding shall be done as per qualified MMAW process approved by Third Party Inspection agency.

(b) Door opening

The octagonal poles shall have door of approximate 500 mm length at the elevation of 500 mm from the Base plate. The door shall be vandal resistance and shall be weather proof to ensure safety of inside connections. The door shall be flush with the exterior surface and shall have suitable locking arrangement. There shall also be suitable arrangement for the purpose of earthing.

The pole shall be adequately strengthened at the location of the door to compensate for the loss in section.

(c) Material

Octagonal Poles	:	HT Steel Conforming to grade S355JO
Base Plate	:	Fe 410 conforming to IS 226 / IS 2062
Foundation Bolts	:	EN8 grade

(d) Welding

The welding shall be carried out confirming to approved procedures duly qualified by third party inspection agency. The welders shall also be qualified for welding the octagonal shafts.

(e) Pole sections

The Octagonal Poles shall be in single section (upto 11 mtr) There shall not be any circumferential weld joint.

(f) Galvanization

The poles shall be hot dip galvanized as per IS 2629 / IS 2633 / IS 4759 standards with average coating thickness of 100 micron the galvanizing shall be done in single dipping.

(g) Xing type

The Octagonal Poles shall be bolted on a pre-cast foundation with a set of four foundation bolts for greater rigidity.

(h) Top Mountings

The galvanized mounting bracket shall be supplied along with the Octagonal Poles for Installation of the luminaries.

(i) Manufacturing

The pole manufacturing & galvanizing unit shall be ISO 9001: 2000 & ISO 14001 certified to ensure consistent quality & environmental protection.

(j) Service window

A service window of the size 150 mm x 100 mm shall be provided in the base of the pole to allow access to electrical connections and terminations. It shall be covered with GI plate and proper rubber gaskets shall be provided to prevent any ingress of water etc.

(k) Electrical connections

Four-way connectors shall be provided along with Slide lock and 1 no 6 amps SP MCB including 2.5 sq.mm PVC insulated copper conductor wires from the terminal block to the fixture and 2 nos. 32 mm dia. GI sleeves of suitable length shall be provided up to the service window. An earth boss shall be provided on the control plate along with connectors and interrupters.

6.15.10 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.15.11 Lighting System Equipment

Main Lighting Distribution Board and Lighting Panels (AC Phase segregated & DC)

(a) Constructional Features

(i) Boards and panels shall be sheet steel enclosed and shall be fully dust and vermin proof, providing a degree of protection of IP 52 for indoor. Outdoor panels shall in addition be completely weather-proof with a sloping canopy for protection against rain and providing a degree of protection of IP 65. The sheet steel used for frame, frame enclosures, doors, covers and partitions shall be cold rolled 2 mm thick.

(ii) All boards and panels shall be provided with hinged doors for access to equipment. Doors shall be gasketed all round with neoprene gaskets. For the main floor mounted distribution boards with the MCB arranged in tier formation, the hinged door of each unit shall be interlocked so as to prevent opening of the door when the switch shall be ON and to prevent closing of the switch with the door not fully closed. However, a device for by-passing the door interlock shall be provided to enable the operation of the switch with the door open, when necessary, for examination/maintenance. For wall mounting 1-phase ways lighting panels when provided with MCBs, a hinged, latched front door shall be provided with key-locking facility and a slotted Bakelite sheet shall be provided inside. Only the MCBs operating knobs or the fuse cap covers shall project out of the Bakelite sheet slots for safe operation and neat appearance Incomer to lighting panels shall be provided with TPN MCCB with ELCB.

(iii) All accessible live connections/metals shall be shrouded, and it shall be possible to change individual fuses, switches, MCBs from the front of the boards/panels without danger of contact with live metal.

(iv) For floor mounting type distribution boards, adequately sized mounting channels shall be supplied and for wall/column/structure mounting type panels suitable mounting straps shall be provided.

(v) Adequate interior cabling space and suitable removable cable entry plates shall be provided for top/bottom entry of cables through glands and or conduits as required. Necessary number of glands to suit the specified cable sizes shall be provided. Cable glands shall be screwed on type and made of brass.

(vi) Two earthing terminals shall be provided to suit the earthing conductor

(vii) All sheet steel parts shall undergo rust-proofing process which should include degreasing, de-scaling and a recognized phosphate process. The steel works shall then be painted with two coats of Zinc - chromate primer and two coats of final stove-enamelled finish paint of specified colour.

(b) Busbars

(i) Busbars shall be of copper conductor of hard drawn (HD) and high conductivity.All bus bars shall be insulated with close fitting sleeve of hard, smooth, dust and dirt free, heat shrunk PVC insulation of high dielectric strength, to provide a permanent non-ageing and non-tracking protection, impervious to water, tropical conditions and fungi.

(ii) Busbars shall be provided with at least the minimum clearances in air as per applicable standards for 500 V, 3 phase system.

(iii) Busbars shall be adequately sized for the continuous current rating such that the maximum temperature of the busbars, busbar risers/droppers and contacts does not exceed 85° C under site reference ambient temperature.

(iv) The busbars, busbar connections and busbar support shall have sufficient strength to withstand thermal and electro-mechanical stresses of the fuse/MCB's let through/cut-off current associated with the specified short-circuit level of the system.

(v) Busbar supports shall be made from suitable insulating material such as Hylam sheets, glass reinforced moulded plastic materials, permali wood or cast resin. Separate supports shall be provided for each phase of the busbars. If a common support shall be provided for all three phases, anti-tracking barriers shall be incorporated.

(vi) The neutral bus of the main 3 phase, 4 wire distribution board shall be rated not less than 50% of the phase busbars. The neutral bus of the 1 phase ways lighting panel shall be rated same as the phase busbars. The neutral bus should have sufficient terminals and detachable links for full number of single-phase outgoing lighting circuits.

Panels/Boards' Component Equipment

(a) Miniature Circuit Breakers (MCB) / ELCB / RCCB

(i) MCBs shall be hand operated, air break, quick make, quick break type conforming to applicable standards

(ii) The switch shall be protected by fuse and the MCB shall be provided with overload/short-circuit protective device for protection under overload and short-circuit conditions. The minimum breaking capacity of MCBs shall be 10kA rms at 415V/220V DC.

(iii) Switch shall have provision for locking in both fully open and closed positions. MCBs shall be provided with locking facility

(iv) The incomer shall be MCCB for ≥ 63A and shall be MCB TPN for <63A connections shall be phase segregated shall be insulated and all live connections shall be shrouded RCCB with suitable rating shall be provided for incomer 100mA and power receptacle feeder 30mA One digital type energy meter shall be provided on each lighting MCB DB.

(b) Fuses for DC

(i) Fuse less system shall be preferable however some special case fuses can be used. Fuses generally shall be of the HRC cartridge fuse-link type having a certified rupturing capacity of 80kA at 440V. Fuses upto 63A for distribution systems of medium short circuit levels may be

of HRC link type, having a certified rupturing capacity of not less than 46kA at 440V and 16kA at 250V DC.

(ii) Fuses shall be provided with visible indication to show that they have operated.

(iii) Insulated fuse pulling handle shall be provided for each size of fuse for each switchboard.

(c) Indicating Instruments and Meters (Digital)

(i) Whenever required, digital instruments and meters shall be of the flush mounting type They shall be suitably mounted so as to provide for easy access to CTs and small wiring.

(ii) Instruments such as voltmeter and ammeter shall be of digital instruments.

(iii) Watt-hour meters shall be of direct reading of digital multifunction meter.

(d) Instrument Transformers

(i) Current and voltage transformers shall be of the dry type, of metering accuracy class 10 Unless otherwise specified, it shall be the responsibility of the Contractor to ensure that the VA burden of the instrument transformer shall be adequate for the meters connected to it.

(ii) Test links shall be provided in both secondary leads of the CTs to easily carry out current and phase angle measurement tests. Facilities shall be provided for short-circuiting and grounding the CTs at the terminal blocks.

(iii) Voltage transformers shall be provided with suitably rated primary and secondary fuses.

(e) Indicating Lights

Indicating lights shall be of the clustered LED type with translucent covers

(f) Internal Wiring.

(i) Panels/boards shall be supplied completely wired, ready for the external connections at the terminal blocks. Wiring shall be carried out with 650/1100V grade, PVC insulated, stranded copper conductors of adequate sizes shall be used to suit the rated circuit current.

(ii) Engraved identification ferrules marked to correspond with the wiring diagram shall be fitted at both ends of each wire.

(iii) All wiring shall be terminated on terminal blocks. Terminal blocks shall be one piece moulded rated 500 V, of reputed make, preferably stud type for higher current ratings such that wires are connected by cable-lugs and complete with nuts and washers. Terminals shall be adequately rated for the circuit current; the minimum rating shall be 20A.

(iv) Terminals for circuits with voltage exceeding 125V shall be shrouded.

(v) Terminals shall be numbered and provided with identification strip for identification of the circuit.

(vi) Terminal blocks for CT secondary lead wires shall be provided with shorting and disconnecting/earthing facilities.

Labels & Diagram Plate

(a) All door mounted equipment as well as equipment mounted inside the switchboard/panels shall be provided with individual labels with equipment designation/rating. Also the boards/panels shall be provided on the front with a label engraved with the designation of the board/panel.

(b) Labels shall be made of non-rusting metal, 3-plylamicoid or engraved PVC.

(c) Inside the door of the 1 phase ways lighting panels a circuit diagram/description shall be fixed for reference and identification.

Light Control box and switches

(a) Light control switches of ratings and types, i.e. decorative/industrial shall be supplied as required. The switches shall be Modular suitable for use on 240V, 1Ph, 50Hz supply.

(b) Switches shall be of flush type for mounting behind an insulated modular plate or incorporated with a switch plate for mounting flush with the surface of wall or switch box/suitable enclosure. The modular switch box / enclosure may be recessed into or mounted on a wall as per the requirement of project layouts.

(c) The size of enclosure modular boxes shall be chosen to accommodate the number of switches to be installed at the particular location. The enclosures shall be 18 gauge sheet steel galvanized. The enclosure plates / boxes shall be fabricated out of quality tested raw material such as metal, PVC, power coated metal. An enclosure intended for surface mounting shall not have holes or gaps in its sides other than those expressly provided for cable entry.

Receptacle Units

(a) Receptacle units shall consist of socket outlet with associated switch and plug. The socket outlet and switch (5/6A) or MCB (15/16A) shall be flush mounted within galvanized 18-gaugesteel / modular enclosure with insulation cover. The box may be recessed into or mounted on a wall as per requirements of project layouts.

(b) The receptacle units shall be suitable for 240V, 1ph - N, 50Hz, 5/6A / 415V, 3Ph – N, 50Hz, 15/16A supply as required.

(c) Single phase receptacles 15/16A shall be associated with ELCB and MCB of same current rating and the receptacle shall become live only when the associated ELCB and MCB shall be in “ON” position.

(d) Three phase receptacles shall be metal clad associated with a TPN MCB housed in the same enclosure. The receptacle shall become live only when the associated MCB switch shall be in “ON” position.

(e) The plugs shall be provided along with three phase receptacle with cord grips to prevent strain and damage to conductors/wires at connection and entry points.

Lighting Wires

(a) The wires for wiring in lighting system shall be 1100 volt grade ISI make, 1/C, PVC insulated, un-armoured with stranded copper conductors.

(b) The minimum area of conductors shall be 15 sq.mm for light fittings and 5/6A Receptacles and 25 sq.mm for receptacles rated 15/16 A and above.

(c) The wires shall be coded white for phase/positive of DC and black for neutral/negative of DC.

Conduits

(a) Rigid non-metallic conduits and their associated fittings as required shall conform to applicable standards. The minimum size of conduit shall be 20 mm for surface installation and 25 mm for concealed installation.

(b) Non-metallic conduits shall be supplied in standard lengths of 5 m of 25 mm thickness and shall conform to IS 2509.

(c) Supply of conduits shall include all associated fittings like couplers, bends and tees as required for lighting system installation work inclusive of all the consumables such as adhesive tape / paste, rawal plug, screws etc.

Junction Boxes

(a) Square or rectangular type modular Junction boxes with terminals shall be supplied for branching and terminating lighting cables when required for indoor / outdoor areas, 3 phase receptacles etc.

(b) The junction boxes shall be dust and vermin proof and shall be fabricated from quality tested raw material such as metal, PVC and powder coated metal and shall be complete with

removable cover plate with gaskets. Boxes shall be additionally weather proof with earthing terminals.

(c) The boxes shall have provision for wall, column, pole or structure mounting and shall be provided with cable/conduit entry knock outs, terminal blocks, earthing terminals as required.

(d) The terminal blocks, with specified number of terminals, shall be mounted securely on brackets welded to the back sheet of the box. The terminals shall be 600 V, grade, one piece construction complete with terminals, insulation barriers, galvanized nuts, bolts and washers and provided with identification strips of PVC The terminals shall be made of copper alloy and shall be of box clamp type.

(e) The boxes shall be aesthetic look and weather proof for outdoor unit with MCB for branching lighting circuit.

6.15.12 Drawings and Data

All Drawings, data, technical particulars, calculations, detailed literature, catalogues, test certificates etc shall be submitted along with the bid/ after award of contract as specified under "Bid/Contract Drawings", Part 3, General Requirements, Volume-2 of Bid Documents.

6.15 Renewable Energy Capability

6.16.1 Solar PV Rooftop system for street lighting only

- The available shadow free roof top area shall be utilized to harness the solar energy. This shall provide a clean and renewable source of energy. The system shall comprise of PV Module (Thin film, poly crystalline), Power Conditioning Unit, and Solar Inverter with necessary accessories. The components shall be as per MNRE approved makes. The solar roof top system shall be grid connected based on Net Metering Regulation of MPERC as amended up to date.
- The PV modules used shall of ≥250Wp ratings as per MNRE or MPERC guidelines, the stricter one to be followed. The PV modules shall be poly-crystalline, thin film with efficiency assurance of 15%. The installation shall have proper space provision such that maintenance shall be easy as the same shall ensure non reduction in PV panel efficiency.
- The street lighting shall be fed on independent radial buried cable circuits fed and controlled from a street lighting switchboard. The cables laid for outdoor lighting application shall be wire armoured.
- Each circuit shall be contactor switched, controlled by an astronomical timer and manual- auto control selector switch. The contactor, time switch and manual control switch for each area shall be incorporated in the LV road lighting distribution switchboard.
- Street lighting shall be Centralized, on grid solar power supply system suitable for power supply to required number of street lights to illuminate the complete treatment facility.Necessary interlocks shall be provided between main supply and solar supplyin such way that solar energy shall be used always and switchover to EB source automatically, when there shall be no solar energy available.

16.6.2 The Centralized solar lighting systems shall comprise:

(i) Solar modules.
(ii) Batteries (for 12Hr back up, SMF lead acid type).
(iii) Inverter.
(iv) Cables.

(v) Required protection and control devices (Short circuit, reverse polarity, battery over charging, deep discharging etc) and wiring work.

Solar module shall convert solar energy into electrical energy and store into the battery. During the night time stored energy shall be converted to AC using efficient inverter and shall be supplied to the street lights. The system shall be powered from the normal grid supply in case of cloudy days or in case of insufficient day light to charge the battery. Roof of "**ADMIN BUILDING"**of STP area can be used for solar cell.

6.16 Earthing and Lighting Protection System

6.17.1 General

The earthing and lightning protection system covers earthing conductors, earth electrodes and accessories. Metallic frame of all electrical equipment shall be earthed by two separate and distinct connections to earthingsystem; Crane rails, tracks, metal pipes and conduits also shall be earthed at two points Steel RCC Columns, metallic stairs and rails of the building housing electrical equipment also shall be connected to nearby earthing grid conductor. Metallic sheaths/ screens and armour of multicore cables shall be earthed at both ends. Metallic sheaths and armour of single core cables shall be earthed at the switchgear end only. Every alternate post of switchyard fence shall be connected to the earth grid by GS flat and gates by flexible lead to earthed post. Each Continuous laid length of cable tray shall be earthed at minimum two places by GS Flats to earthing system; the distance between the earthing points shall not exceed 30m Lightning Protection System shall compromise vertical / horizontal air terminations, down conductors, test limits and earth electrodes Air terminations, down conductors and test links shall be of galvanized steel conductors and earth connection below the ground level shall be of mild steel.

Lightning Protection System down conductors shall not be connected to other earthing conductors above the ground level.

6.17.2 Applicable Standards

The earthing and lightning protection system shall conform to the Indian Electricity rules, and the latest applicable standards indicated below:

Code of Practice for Earthing	:	IS:3043
Code of Practice for the Protection of Building and allied structure against lightning	:	IS:2309
Hot dip galvanizing	:	IS:2629, 2633, 4759
Structural steel	:	IS:2062& 808
Welding	:	IS:816

6.17.3 Earthing Conductor

The electrical installation shall where required be connected to the general mass of the earth by an earthing conductor The material used for the earthing conductor shall be as follows:

(a) Conductors above ground shall be galvanised steel flat.

(b) Conductor buried in the ground or embedded in concrete shall be galvanised steel, rod/flat. Allowance shall be made for reduction in the cross section of the steel over the design life of the earthing system.

The earth electrode system shall comprise one or more earth electrodes, earthing network, mesh or a combination of these in order to obtain the required earth electrode resistance.

Earth electrodes where used shall be of heavy duty galvanised mild steel of not less than 40mm NB and 3000mm long. Where multiple electrodes are used, they shall be separated by a distance of not less than the driven length.

Each earth electrode pipe shall be welded at the top to a mild steel plate to which the earthing tapes shall be connected. These connections shall each be housed in individual concrete inspection chamber set flush to the finished ground level and shall allow disconnection for testing of individual electrodes. The chamber shall be permanently marked 'Electrical Earth'.

All materials used for the earth electrode installation shall be purpose made for the application and site conditions and shall be approved by the Employer's Representative.

Unless otherwise stated all excavation for the installation of the earth electrodes and the inspection pit shall be carried out by the Contractor.

After the earth installation has been completed the Contractor shall demonstrate to the Employer's Representative that the resistance of the electrodes to earth and the continuity of the earth network are within the limits specified. Any additional earth electrodes and test instruments required for the tests shall be provided by the Contractor.

Marker posts and plates shall be provided to mark the route of buried tape or conductor electrodes. The markers shall be similar to those provided for cable routes.

6.17.4 Lightning Protection System

(i) The need of lightning protection has been established by calculating the overall risk factor as per IS/IEC 62305.

(ii) Air termination system comprising of rods/mesh or combination of both shall be provided and the methods used to determine the positioning of Air termination system shall be as per IS 62305.

(iii) Air termination system shall be connected to the earthing system by down conductors fixed along the outer surface of building Number & layout of the down conductors shall be as per IS/IEC 62305.

(iv) Each down comer shall be terminated to a separate treated test earth electrode which in turn shall be connected to station earthing system.

(v) The link shall be provided in the run of each down conductor at approximately 1000 mm above ground level.

6.17.5 Main Equipotential Bonding Conductor

Main equipotential bonding conductors shall be provided to connect the earth electrode system to conductive parts forming the works.

Equipotential bonding conductors shall have the following **minimum sizes**

(a) Main Equipotential Conductors

- Main Earth Conductor buried in earth — 40 mm dia MS Rod
- Transformers, main switchboard and standby generator installation — 50 x 10 mm flat
- interconnection to lightning protection system — 50 x 10 mm flat

-	interconnection to MCCs	50 x 10 mm/50 x6mm flat
(b)	Equipotential Conductors	
-	interconnection to CPs	25 x 3 mm flat
-	power factor correction capacitor panel	25 x 3 mm flat
-	local push buttons	14 SWG wire
-	lighting distribution board	4 SWG wire
-	lighting and receptacle system	12 SWG wire
-	outdoor street lighting	8 SWG wire
-	ladder rack and cable tray at suitable points	25 x 3 mm flat
-	hand rails and metallic structures	25 x 3 mm flat
-	building reinforcement	25 x 3 mm flat
-	incoming and outgoing process services	25 x 3 mm flat
-	steel structures comprising storage tanks, mezzanine platform, crane rails, air handling ductwork systems etc	25 x 3 mm flat
(c)	LV Motors	
-	up to 10 kW	8 SWG wire
-	10 to 20 kW	4 SWG wire
-	20 to 50 kW	25 x 3 mm flat
-	Earth electrode	40mm dia 3000 mm long heavy Duty GI pipe electrode

Notes:

1. Equipotential conductors shall interconnect between the device to be bonded and the main equipotential conductor.
2. Connections to building structural steelwork or concrete reinforcement shall be made by a bolted connection to a tag welded to the steelwork or reinforcement bars. Unless otherwise specified at least two connections shall be made to the steelwork and reinforcement bars at the perimeter of each building at diagonally opposite locations.

6.17.6 Circuit Protective Conductors

An independent circuit protective conductor shall be provided for each circuit and may comprise one or any of the following as appropriate:

- a separate core within a multicore cable.
- a separate conductor installed within a conduit or trunking Steel conduit or trunking shall not be used as a circuit protective conductor.
- the metal sheath of an armoured cable The sheath shall be bonded to the metalwork of the apparatus and to the apparatus earth bar if any.
- the copper sheath of a mineral insulated copper sheathed cable.
- an independent earthing conductor MS or GS conductor run adjacent to the circuit it protects.

Circuit protective conductors associated with the main circuits supplying switchboards and large electrical loads, i.e. motors in excess of 75 kW shall form a separate core of a multicore cable feeding the device or shall be an independent insulated copper conductor run adjacent to the supply cable. The size of the circuit protective conductor shall be calculated in such a manner as not to take into consideration the contribution of any other parallel or fortuitous earth paths.

The armouring of the supply cable shall not form the sole means of earthing a switchboard or large electrical load.

Where the cable armouring or sheath shall be used as the circuit protective conductor it shall be securely bonded at both ends to the metalwork of the apparatus and to an earth bar. Particular care shall be taken to ensure continuity across items of apparatus situated within a cable run and should the design of such items of apparatus not give adequate and lasting continuity through its structural body then additional earthing clips and conductors shall be provided to independently bond the cable sheaths together. Similarly additional earthing clips shall be provided to bond the cable sheaths/armour to any piece of apparatus fitted with a special earth terminal should the earth connection for the termination gland be inadequate. Any additional earthing clips shall be fitted within the apparatus wherever possible.

6.17.7 Instrumentation Earth

An instrumentation earth bus, if required shall be provided in each control panel. This shall comprise a copper flat of cross section not less than 25 x 6 mm and length to suit the number of connections. It shall be mounted on at least two insulated supports and be provided with a single earth connection to the instrument plate type earth. If due to the physical size of a control panel more than one instrument earth bar shall be required the additional bar shall be connected again with a single earth connection to the same point as before. In this fashion all instrument earths shall be connected radials from the sameplate type earth point.

The earth pit for instrumentation system shall be separate. Electric earth pit shall not be used for earthing of instrumentation equipment. All signal cable screens (analogue and digital) shall be terminated onto the instrument earth bar. Signal cable screens shall be earthed at the control panel end only. Screens at the field end shall be tied back and insulated. Connection between instrument earth bar and instrument plate type earth pit shall be insulated copper wire such that earth pit resistance shall be less than 1 Ohm at panel.

SPD s associated with the control and instrumentation system shall be earthed to the instrument earth in accordance with the SPD manufacturer's recommendations.

6.17.8 Galvanising

Wherever galvanising has been specified, the hot dip process shall be used. The galvanised coating shall be of uniform thickness. Weight of Zinc coatings for various applications shall not be less than those indicated below:

a) Fabricated Steel

Thickness less than 2 mm, But not less than 12 mm	340 gms/sqm
Thickness less than 5 mm, but not less than 2 mm	460 gms/sqm
Thickness 5 mm and over	610 gms / sqm

b) Fasteners

Upto nominal size M10	270 gms/sqm
Over M10	300 gms/sqm

Burrs shall be removed before galvanising. Any site modification of galvanised parts should be covered well by zinc rich primer and aluminium paint.

6.17 Insulating Mat

Insulating mats shall conform to IS 15652. The Supplier shall be made from the material Elastomer and free from any insertions leading to deterioration of insulating properties for floor covering in front or the HV and LV switchgear along its length.

Mats shall be free from fabric insertions and fibrous material and resistant to acid, oil & low temperature. Mats shall be solid and no perforated. The upper surface shall have small aberration (rough surface without edge) to avoid slipper effects while the lower surface shall be plane or could be finished slip resistant without affecting adversely the dielectric property of the mat.

The mats shall have class-D with minimum thickness of 3.5 mm without negative tolerance.

Mats of both types shall have a minimum width of 900 mm. Mats shall be satisfactorily vulcanized, free from blisters, pin-holes, cracks, embedded foreign matter and other physical defects.

Minimum insulation resistance for the mats with tap water (i.e., wet condition) will be of 1,00,000MΩ, when measured with 5000V Megger or 10,00,000MΩ, when measured with 500V Megger.

Insulating mats shall be marked with standard marks and Bureau of Indian Standards number.

6.18 Preferred Makes/Manufacturers

List of preferred makes for Electrical Equipment / Items

SL. NO.	DESCRIPTION	VENDOR / MANUFACTURER / MAKE
1	Distribution Transformers	M/s Crompton Greaves Limited M/S Volt Amp M/S Bharat Bijlee M/S KOTSONS M/s Kirloskar Electric M/s. Vijay power control systems Pvt. Ltd.,
2	11 kV Metal enclosed switchboards	M/s Siemens M/s ABB M/s BHEL M/s Schneider Electric
3	Digital Protective Relays / meters	M/s ABB M/s Schneider Electric M/s L&T M/s GE M/s Siemens M/s Mitsubishi Electric
4	Current Transformers - LT	M/s AE M/s ECS

		M/S KOTSONS M/s Pragati M/s Kappa
5	Voltage Transformers - LT	M/s AE M/s ECS M/S KOTSONS M/s Pragati M/s Kappa
6	LV Switchgears & Control gears (PCC's / MCC's / PDB's)	M/s Schneider Electric M/s ABB M/s Siemens M/s GE M/s L&T M/s Mitsubishi Electric Note: Authorized license partners / System Integrators of above manufacturer's shall be TTP certified for IEC 61439
7	LT Power Capacitors / Panel	M/s ABB M/s CG Power Systems M/s Universal M/s Madhav M/s BHEL M/s L&T M/s Mitsubishi Electric Note: Authorized license partners / System Integrators of above manufacturer's shall be TTP certified for IEC 61439
8	Diesel Engines	M/s Cummins M/s Caterpillar M/s Kirloskar Oil Engines M/s Perkins M/s Crompton Greaves
9	Alternators for DG Sets	M/s Kirloskar Electric M/s CGL M/s BHEL M/s Jyoti M/s Stamford M/s Leroy-Somer
10	Variable Frequency Drives / Soft Starters	M/s Siemens M/s ABB M/s GE M/s Schneider Electric M/s Mitsubishi Electric M/s Yaskawa M/s. Hitachi hi-Rel power Note: Authorized license partners / System Integrators of above manufacturer's shall be TTP certified for IEC 61439
11	Batteries	M/s Exide Industries

		M/s AMCO M/s HBL-NIFE M/s Amara raja
12	Battery Chargers	M/s Universal Instruments M/s Amara raja M/s Chabhi Electricals M/s HBL-NIFE M/s Caldyne M/s Masstech
13	Lighting Fixtures and Accessories	M/s Philips M/s ABB M/s Crompton Greaves Limited M/s Wipro M/s Bajaj Electricals M/s Legrand M/s HK Enterprises
14	LT Bus Ducts	M/s Star Drive M/s Power Gear M/s C & S Electric Limited M/s Udit Engineers
15	Power Cables and Wires	M/s Universal Cables M/s Polycab M/s Havells M/s Finolex M/s NICCO M/s TCL Cables M/s Delton M/s C & S Electric Limited
16	MLDB's, LDB's, SDB's, MCB's, RCCB's	M/s Havells M/s Standard M/s Legrand M/s L & T M/s Siemens M/s Schneider Electric M/s Udit Engineers
17	Switches, Plugs, Sockets, Pushbuttons	M/s Legrand M/s Havells M/s Anchor M/s Cona M/s C & S Electric Limited
18	Pushbutton system	M/s Shrenik and company M/s Udit Engineers
19	LT & HT Panels	M/s. Siemens M/s. Balaji Controls Pvt. Ltd M/S Udit Engineers M/s. Sunshine Controls
20	Ceiling Fans	M/s Havells M/s Crompton M/s Orient

		M/s Bajaj M/s Usha
21	Cable termination Kits	M/s Raychem M/s Mahindra M/s REPL M/s 3M

Note:

All products shall be completely manufactured in the country of Origin as indicated. Assembled products shall not be accepted.

Note-1: In order to achieve standardization for appearance, operation, maintenance, spare parts and manufacturer's service, like items of equipment provided hereunder shall be the end products of one (1) manufacturer.

Note-2: In the event that the contractor wishes to propose alternate makes for the equipment mentioned above, he shall submit the following during detailed engineering:

(i) Copies of Type Test Certificate not older than 5 years for the items offered.
(ii) Demonstrate that the proposed makes are "equivalent" to the approved makes. The contractor shall ensure that alternate makes proposed, shall comply completely to the tender specifications, before the same is submitted for approval.
(iii) Submit ISO certificates for the OEM.
(iv) Submit quality certificates that the equipment adheres to, as required under this contract.
(v) Submit product brochures for the proposed equipment, with information on spares availability and service setup in employer's country.
(vi) Manufacturer involved in manufacture of specified proposed equipment for at least 10 years before bid date
(vii) End user performance certificates for minimum 10 successful individual installations of similar size as per this contract with the proposed equipment and model no, commissioned in last 5 years before bid date and satisfactorily operating for at least five years before bid date. Contractor to submit end user reference certificates for each of the installations referenced.
(viii) Manufacturer to provide full contact information for each reference as part of submission.

End of Part-6